Pollen studies on recent sediments in the western Weald.

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POLLEN STUDIES ON RECENT SEDIMENTS IN THE WESTERN WEALD.

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Abstract.

This study involved the investigation of the recent vegetational history of the Wealden district of West-Sussex, particularly with reference to the effects the post-medieval iron industry had on the woodland of the region. The main source of information was the palynological investigation of various sediments present in the area. To fulfil the aims of the study, sediments from the man made hammer ponds, relics of the regions iron industry, were chosen to provide the material for the bulk of the analyses. When possible these sediments were supplemented by the study of peats and soils associated with the sites studied.

The results of the pollen analysis were statistically analysed using the multivariate technique of detrended correspondance analysis (DECORANA), together with a number of zonation programs. ^{14}C dating was used to provide a temporal framework for the study. Historical records were also used when possible to supplement the information from the pollen analysis.

The pollen studies suggest that rather than causing large-scale deforestation in the region, in the majority of the sites studied, the iron industry had relatively little impact on the local woodland. It appears that the fuel needed for the industry was largely provided by a coppice and standard method of woodland management. However at one site, Combe Pond near Rogate, the establishment of iron works does appear to be associated

with a degree of deforestation.

During the last two centuries the amount of woodland in the area has increased, rather than declined. Areas of former heathland and common appear to have been re-afforested, possibly in response to a decline in the utilisation of areas for grazing.

Evidence is also put forward from one of the sites that suggests a possible mid to late Bronze Age origin for some of the heathland in the region.

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CHAPTER 1 - INTRODUCTION.

1.1 Aims.

The thesis presented here is the result of a study of the recent vegetation history of the western area of the Wealden district of South East England (see Fig. 1.1). Details of this region and the position of the sites selected for this study will be given in Chapter 2. The reasons for carrying out such a study in this area are outlined in this chapter.

Traditionally pollen analysts have been mainly interested in the vegetation changes in the earlier parts of the present interglacial and in previous Pleistocene glacial/inter-stadial or interglacial sequences. Relatively little attention has been paid to the production of pollen diagrams covering the more recent past such as the post- Medieval period. There are a number of reasons for this, firstly the presence of archival documentation can often provide detailed information of land management. Such detail is not often obtained from the pollen analysis of peats, largely due to the relatively broad sampling intervals used by palynologists (Scaife, 1987). Although humification and compaction will be least important in the upper levels of peat deposits, the slow growth rate of many such deposits means that an average sampling interval of around 4cm will be too great to give precise temporal definition. An added problem is that the upper portions of peat deposits

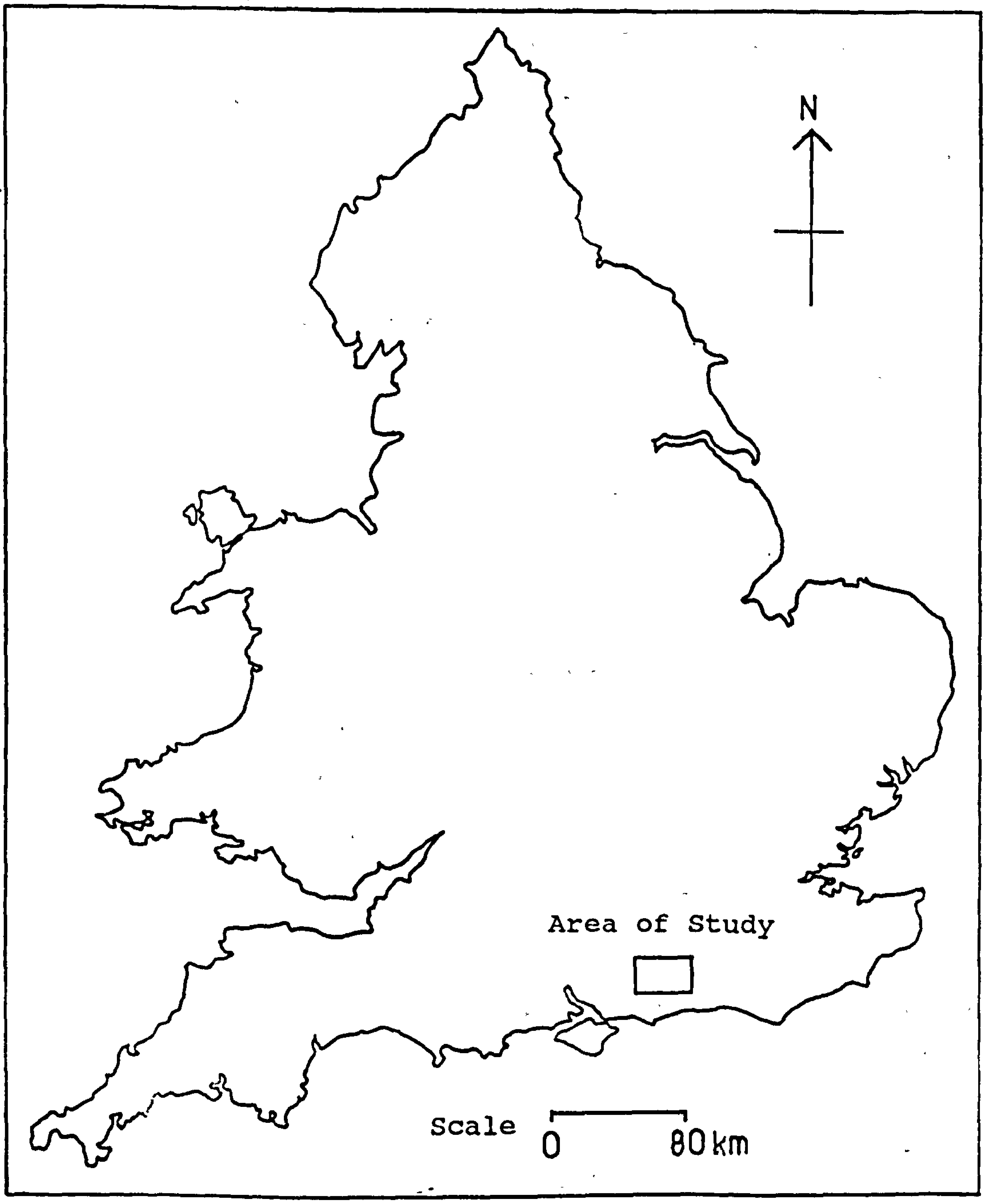


Fig. 1.1 Map of England and Wales showing area covered by this study.

can be often rather disturbed. Drainage can cause the desiccation of the upper levels, which will lead to the oxidation of the upper peats and often peat deposits have been cut for fuel. The palynological investigation of soil proves to be less satisfactory in obtaining good temporal definition, due to the lack of true stratification in such deposits (Dimbleby, 1985).

Therefore, it was hoped to find sedimentary deposits that might be able to offer the potential for detailed study of the recent past. Obviously the choice of sites is very important in any palaeoecological study. Jacobson and Bradshaw (1981) pointed out that at the beginning of such a research project two critical decisions must be made:

1.defining as precisely as possible the questions to be asked of the data, and

2.finding the sites that can provide the best data to answer those questions.

The area of the Weald, investigated here, was chosen for this study for a number of reasons. Firstly, compared to the upland areas of Britian, relatively few sites in Southern England have been investigated palynologically. Scaife (1987) recognised this problem and suggested the following reasons why this was the case. Lowland South East England has a summer rainfall deficit, which mainly accounts for the lack of ombrotrophic and blanket peat bogs in the region. The absence of major glacial erosion in the area precluded the development of deep peat and sediment accumulations which developed in glacial geomorphological situations (eg. overdeepened valleys, corries/tarns, lakes) elsewhere. Much of the geological strata in the area are rather calcareous; such strata produce alkaline hydrological and sediment conditions generally detrimental to pollen presevation. Finally recent human pressure, such as drainage and peat cutting, has disturbed many of the exisisting areas of peat in the region. Therefore, although this study is predominantly concerned with the last few centuries, information useful in filling gaps in the knowledge of the areas vegetation history may be recovered.

Secondly, this study was hoped to complement the work of Moseley (1987, Moseley and Moore, 1988), who investigated the recent vegatation of the northern part of the Weald, more specifically that of the ridge formed by the Hythe Beds of the Lower Greensand. This study was partially designed to add information about the vegetation history of the corresponding geological formation from this part of the Weald, and also to provide information from other geological outcrops in the Weald.

The third, and main, reason was the area's former iron industry. The activites of this industry are well documented by Straker (1931). The former iron industry is relevant for two reasons: firstly there has been some discussion about what effects this industry had on the vegetation of the region. The iron industry in the region was energy intensive: two major processes were involved in the production of iron. Firstly the iron ore was smelted in charcoal fuelled furnaces to produce pig iron, then the raw pig iron was processed at sites known as iron hammers or forges. At the iron hammers the pig iron was re-heated and impurites removed by beating the metal with a large mechanical hammer (Straker, 1931), again charcoal was the major fuel used in the process. It was the source of the charcoal used that has been a cause for discussion. The iron industry has often been blamed for the deforestation of large areas of the Weald. Conversely, it has been pointed out that if the fuel was derived from forest trees, the local supply of fuel would quickly be exausted and charcoal would have to been transported to the industry which would be less economically viable. However, if the fuel was derived from local coppice, the supply would be close to the iron works and renewable, a definite advantage. It was therefore hoped that this study may provide palynological evidence to support one or other of these views. The other major influence of the iron industry on this study is the presence of any artificial ponds known, as Hammer ponds, in the area. These ponds were associated with both the furnaces and forges as a source of energy. They provided a head of water to power waterwheels which operated bellows in the case of the furnaces, and the mechanical hammers in the case of the forges (Straker, 1931).

The presence of these ponds offered a number of advantages to this study:

(I) They are relatively widespread and numerous, allowing one to choose a suite of sites relating to the different geological formations and soil types of the area and therefore highlight any possible differences in vegetation development due to such variation.

(II) As these ponds are associated with the iron industry, they are ideally placed to investigate what effect the industry had on the vegetation.

(III) Being comparatively recent man-made structures, but often containing deep sediments, it was hoped that their pollen stratigraphical study would give a high temporal resolution to the data obtained.

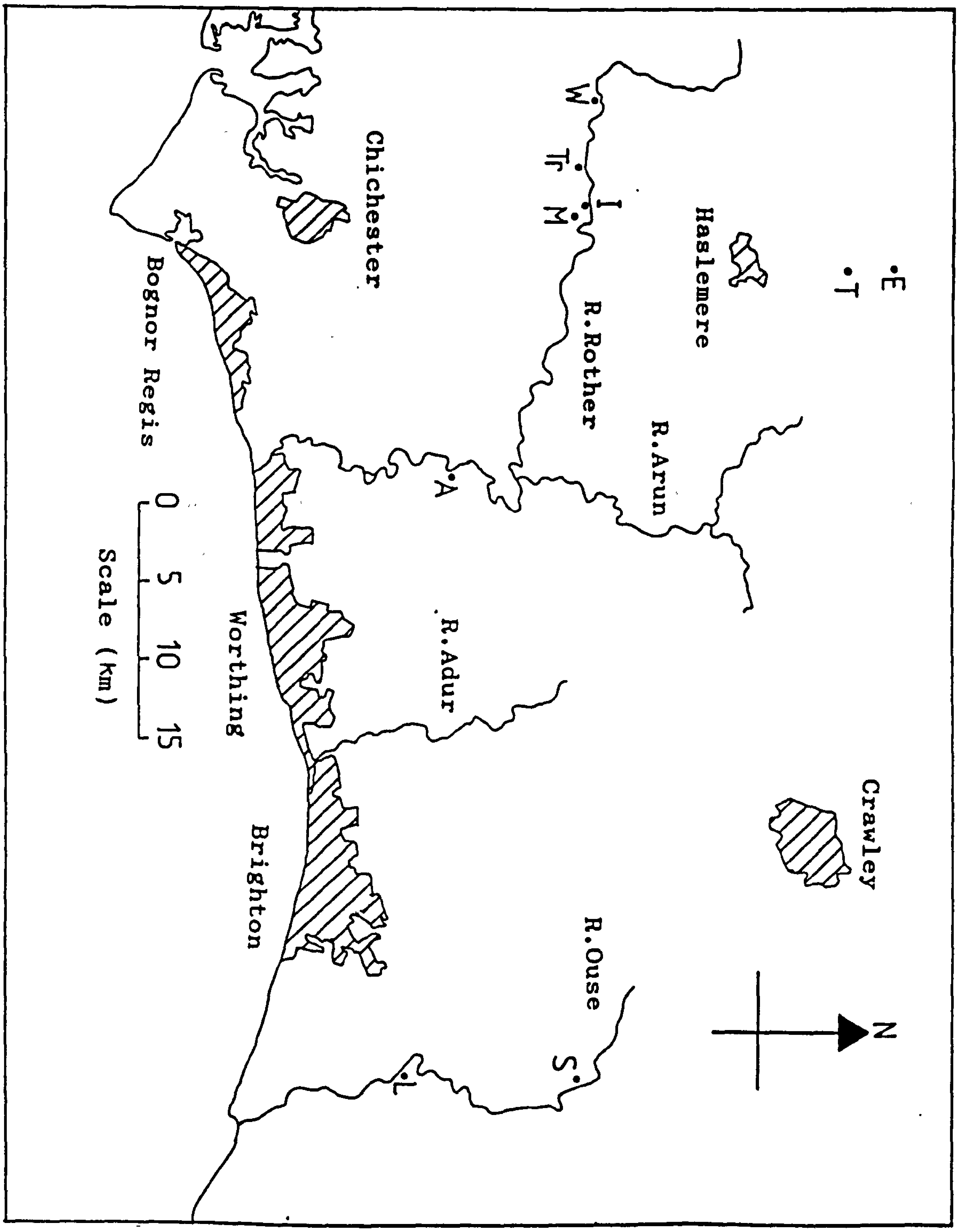
(IV) Due to the lateral movements and mixing inherent in lake sediments, such as those found in these ponds, Moore and Webb (1978) suggested that one can reasonably justify a single core as being representative of the entire basin.

Therefore, it was on the sediments of such hammer ponds that the bulk of this study is based. However, whenever possible it was hoped to supplement the information from these sediments with data obtained from the investigation of deposits such as peats, mor humus and soils that may be associated with any of the sites.

Whenever possible it was also hoped that the results of the pollen analysis could be compared with historical records pertaining to the sites.

1.2 Previous Studies.

Although, as previously mentioned, relatively few



<u>Fig. 1.2 Sites of Previous Pollen Studies in Study Area</u>

<u>Key</u>

E - Elstead (Seagrief and Godwin, 1960; Carpenter and Woodcock, 1981)

Fig. 1.2 Key (cont.)

T - Thursley (Moore and Willmot, 1976)

W - West Heath (Baigent in Drewett, 1976; Scaife, 1983; Scaife in Drewett, 1885; Scaife and Macphail, 1983)

Tr - Trotton (Keating, 1983)

M - Minstead (Dimbleby, 1975)

I - Iping (Keef et al., 1965; Dimbleby, 1975)

A - Amberley Wild Brooks (Thorley, 1981; Walton, 1982)

S - Sharpsbridge (Burrin and Scaife, 1984; Scaife, 1983; Scaife and Burrin, 1983)

L - Lewes (Thorley, 1971, 1981)

sites have been investigated palynologically in South East England compared to upland Britain, a number of peats and soils have been investigated in the region. Most of these studies are discussed by Scaife (1987) in his review of the published (and some unpublished) pollen studies from southern England. It would be of little value to repeat much of this study here, especially as the geographical areas and time periods covered by many of these studies fall out of the scope of this investigation. Some of the sites investigated most pertinent to this study are shown in Fig. 1.2.

Since the review by Scaife (1987), relatively few pollen studies have been published from the Wealden district, however more recent work includes that of Smyth (1988) and Moseley and Moore (1988). It is the work of Moseley (1987) that is perhaps of most relevance to this study. Like this study, that of Moseley was mainly concerned with relatively recent changes in vegetation history. Concentrating on the Hythe Beds of the Lower Greensand, Moseley mainly investigated mor humus deposits from the forest ecosystems that cover much of the hills that make up the ridge. He found that the woodland was secondary, developing in the 18th and 19th Centuries, on land formely dominated by heathland vegetation. Enclosure of the land and a drop in grazing pressure are put forward as the most likely reasons for the loss of the heath.

Whether a similar pattern of vegetation change to that found by Mosely would be found on the Lower

Greensand formation in the area studied here was initially not thought to be likely. It was expected that any increase in tree cover found would most likely be due to plantation, mainly of conifers, rather than an increase in secondary woodland. Information on the past vegetation of the area of Weald Clay, however, was expected to be particularly valuable as very little previous work has been carried out on this area.

CHAPTER 2 - SITES AND AREA OF STUDY.

2.1 Sites.

The area chosen for study is the western region of the Wealden district of South East England. The sites investigated are all located in the county of West Sussex, and are associated with the area drained by two rivers, the Western Rother and the Arun. Fig. 2.1 gives a sketch map of the area of study. It also shows the position of the sites investigated and gives an impression of the areas topography and drainage.

The sites can be divided into two main groups, three sites located on the Lower Greensand formation, and three sites located on the Weald Clay (a description of the geology of the area is given below). The first group comprises Burton Mill Pond, found about 3 kilometres south of Petworth, a pond known as Hammer Pond near the village of Iping and a shallow peat deposit on Black Moss about 4 kilometres south of Haslemere. The second group is made up of the pond at Harting Combe near Rogate, Furnace Pond near Fernhurst and an unamed pond near the village of Ebernoe. All the sites, with the exception of Black Moss are examples of the Hammer Ponds mentioned in Chapter 1. It was hoped that this group of sites would give a good north-south and east-west spread across the area.

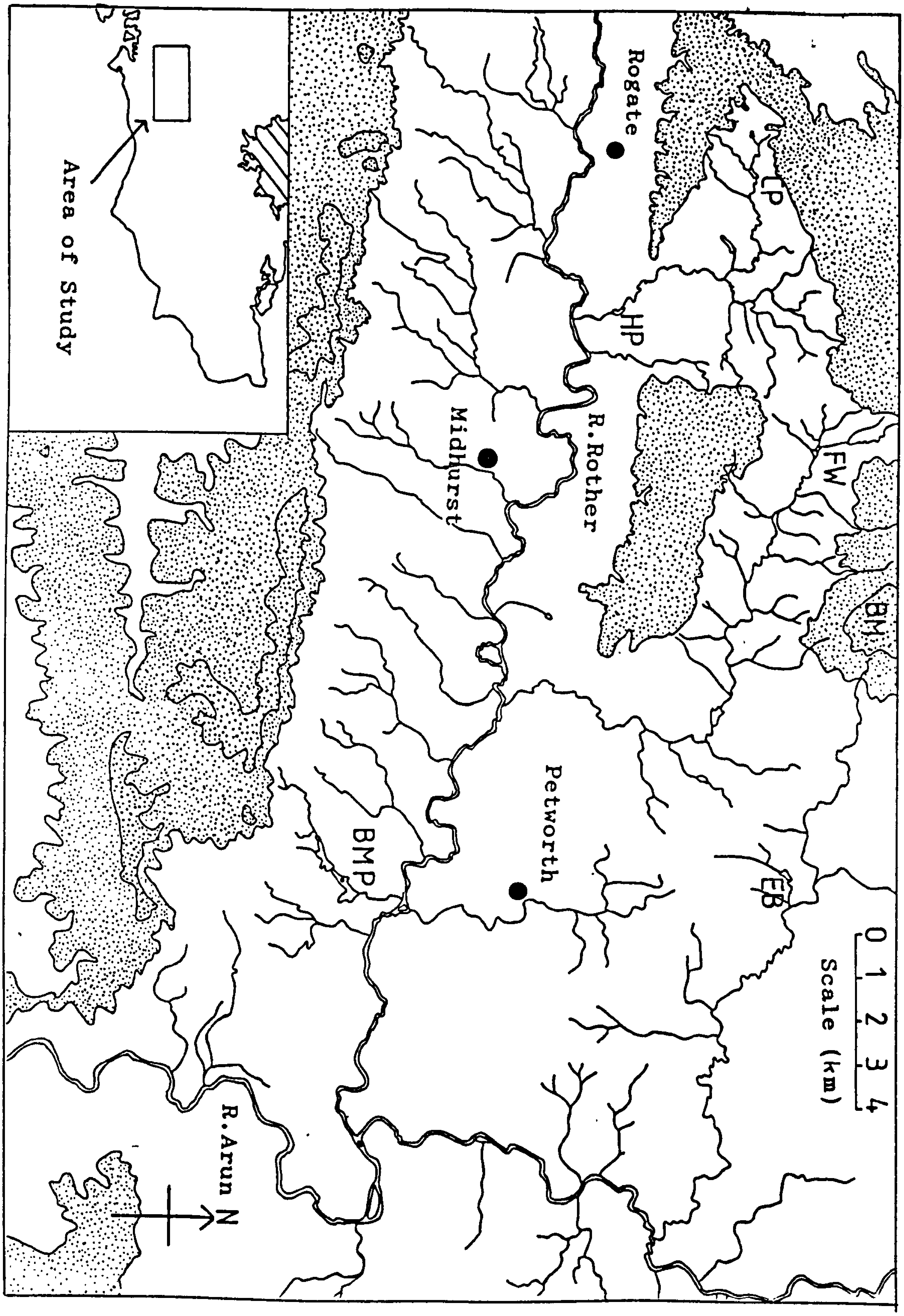


Fig. 2.1 Sketch map of the Western Weald showing the location of study sites.

(Key overleaf)

Fig. 2.1 (cont.)

Key.

CP - Combe Pond

HP - Hammer Pond

FW - Furnace Wood Pond

BM - Black Moss

EB - Ebernoe Pond

BMP- Burton Mill Pond

2.2 Geology.

A geological sketch map of the area of study is given in Fig. 2.2. To understand the geology of this area, the structure of the Wealden system as a whole must be first considered. However, due to the nature of this study only the strata exposed at the surface need be discussed. The majority of these deposits date from the Mesozoic era. Originally they were deposited on a downwarped platform of earlier Palaeozoic rocks, then, in the Tertiary era, a period of uplifting and folding of these strata produced a structure known as the great Wealden dome. This has since been eroded to produce the structure we see today.

The Chalk of the North, West and South Downs frames the area. Moving towards its centre, one then passes the sucessive outcrops of rocks originally below the chalk. In descending order these are: the Upper Greensand, the Gault, the Lower Greensand, the Weald Clay and the Hastings sands. The last two make up what is known as the Wealden Formation. The Hastings Sands form the core of the Weald, the higher strata forming roughly concentric zones around them. A brief description of the strata occurring in the region covered by this study will now be given:

The Wealden Formation.

These are lacustrine and deltaic deposits derived from earlier Palaeozoic and Mesozoic sediments. Although the Wealden is made up of the Hastings sands and the

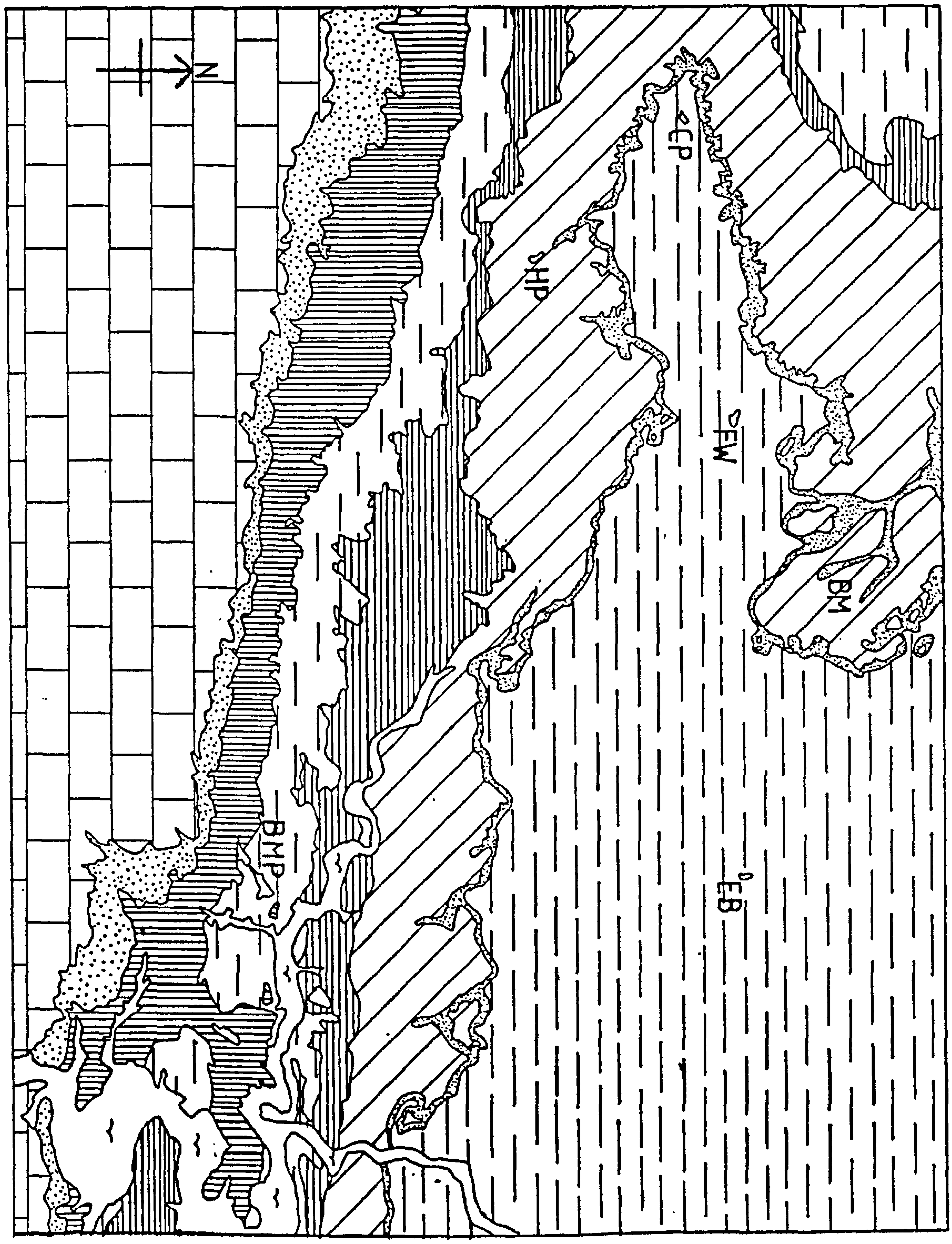


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Fig. 2.2 Geological Sketch Map of the Western Weald. (Key overleaf)

Fig. 2.2 (cont.)

Key.

Geology.

Weald Clay

Athefield Clay
Hythe Beds
Sandgate Beds
Folkestone Beds

Lower Greensand

Gault Clay

Upper Greensand

Chalk

Alluvium

Sites.

CP - Combe Pond	HP - Hammer Pond
FW - Furnace Wood Pond	BM - Black Moss
EB - Ebernoe Pond	BMP- Burton Mill Pond

Weald Clay, only the Weald clay outcrops in the area of study. The Weald Clay consists of shales and mudstones with less important ammounts of siltstones, sandstones, shelly limestones and clay ironstone. The minor sandstone belts are important as they provide lighter and more readily cultivatable soils than the clays, and afford local supplies of underground water.

The Lower Greensand.

There are four divisions recognised in the Lower Greensand; in ascending order they are: the Atherfield Clay, the Hythe Beds, the Sandgate Beds and the Folkestone Sands.

The Atherfield Clay does not differ greatly in character from the underlying Weald Clay. It contains, however, distinctive bands of smooth chocolate-coloured clay, together with fine sands and silts and hard concretions of marine fossils.

In the area studied, the succeeding Hythe Beds consists of 'hassock', a loamy sand. Elsewhere the hassock alternates with of layers of limestone, known as Kentish Rag. The distinction is important, as the two lithographies give rise to very different types of topography and soil.

The Sandgate Beds also prove very variable. They generally comprise of sandy clays, and contain local developments of Fullers Earth. They change to the west, in the development of a local type known as the Bargate Beds. These are coarse pebbly sands with include bands of oval 'doggers' of sandy limestone (Bargate stone). The

Bargate Beds are continously traceable around the Western end of the Weald, but east of Arun they cannot be separated from the underlying calcareous Hythe Beds. Above them, around Midhurst, are coarse, highly ferruginous sands followed by further sands and clays.

The Folkestone Sands are the most consistent of the Lower Greensand divisions. They comprise fairly coarse sands, and throughout most of the outcrop the only hard stone they contain are bands and concretions of dark brown sandy ironstone known as Carstone.

The Gault and Upper Greensand.

The Upper Greensand is the equivalent of part of the Upper Gault rather than a distinct and successive formation. The Lower Gault is everywhere a stiff clay, then comes a bed of phosphatic nodules marking a sharp break in the fossil fauna. Above this the Upper Gault is a marly clay and at Folkestone this passes up into a true marl, ie. a highly calcareous clay. Further west this marl becomes sandy or silty upwards and passes without a break into the Upper Greensand, which is essentially a sandstone of the same age as the topmost marl at Folkestone.

The Chalk.

The chalk builds the Wealden frame. For our purposes the chalk can be divided into three main bands: the Lower Chalk, the Middle Chalk and the Upper chalk.

The Lower Chalk is equivalent to the Chalk Marl and Grey Chalk of the early writers. These beds differ in both colour and consistency from the mass of pure white chalk above. The Chalk Marl is a true marl, an impure limestone containing 30-40% mud

The Middle Chalk is a relatively pure limestone without flints. At its base is a band of hard nodular crystalline chalk known as Melbourne Rock.

The Upper Chalk is what used to be referred to as the 'Chalk with Flints'. The flint which occurs in bands and nodules throughout the Upper Chalk is derived like the chert of the Hythe and Folkestone Beds from the remains of siliceous sponges.

2.3 Soils.

As would be expected the soils of the area are locally very variable, however generally they can be related to the underlying rocks.

The Weald Clay and associated deposits give soils known as stagnogleys, characterised by poor drainage, waterlogged for six months most years due to the impermeable substrata. They are difficult to work agriculturally.

The Hythe Beds of the Lower Greensand produce mainly podzolic soils, with some brown sands, particularly if the soil is being used agriculturally. Modification of the podzolic profile occurs under tree plantation, for instance under chestnut coppice soils often show signs of improving to brown sand or podzolised brown sand, while under conifer plantation podzols are deeper and more intense.

The Sandgate beds in some areas are avoided for agriculture, but in the Rogate area there is a distinct agricultural band between the agriculturally poor Folkstone and Hythe beds. The soils tend to be brown sands with poorly differentiated horizons and little evidence of clay illuviation. The soils seem to be often subject to considerable erosion.

The Folkstone Sands give a distinctive soil association. The soils are predominantly podzols often associated with *Calluna* heaths and coniferous woods. A full range of podzolic profiles are present on most commons. Variation in drainage conditions associated with minor variations in the parent material gives a degree of gleying superimposed on the podzolisation. The commonest profile is the normal podzol. Under undisturbed heathland or coniferous woodland, there is an accumulation of mor type humus at the surface with clearly defined L., F. and H layers, with an abrupt boundary to coarse textured grey sand, often with some organic staining in the upper parts. Below this horizon normally a two-fold illuvial horizon occurs, with a distinct dark reddish brown zone of iron accumulation, often indurated, overlain by a dark brown to black zone of organic matter accumulation.

Variation also occurs in depth from 20-30cm to over 1m. In some parts of commons and associated woodlands, and more specifically where the soil is used for agriculture, the soils show only slight signs of podzolisation and tend towards brown sands.

The Gault clay gives stagnogley soils, distinctly grey in colour with yellow mottles and iron staining along root channels. In the winter months the water table is near or at the surface in some locations, restricting the decomposition of organic matter, often forming a thin (1-2cm) peat like deposit at the surface.

In the west of the area these deposits are often overlain by a veneer of slightly calcareous, often flinty material, presumably derived from the Chalk and Upper Greensand.

The soils of the Upper Greensand are dominated by brown earths. They often have a high silt fraction and there is occasionaly evidence of limited clay illuviation and is often slightlly calcareous. In locations the soils include loessic deposits and colluvium from the adjacent chalk escarpment. In places where the colluvium has a high clay content, the drainage is imperfect and gleying occurs in wetter years.

Rendzinas and brown calcareous earths occur on the chalk. In this area the rendzinas are shallow, calcareous soils formed on the materials of the chalk escarpment. In many places, in complex with the rendzinas, there are brown calcareous earths where the topography has allowed the accumulation of chalky colluvium.

CHAPTER 3 - METHODS.

3.1 Field Work.

Peat and lake sediment cores were recovered by the use of a 'Russian borer' (Jowsey, 1966). In the cases of the pond in Harting Combe, and Hammer Pond, Chithurst sampling took place on a day when there was sufficient ice cover on the ponds to allow one to walk out onto the pond and sample through the ice. Furnace Pond, Fernhurst and the Pond at Ebernoe were both rather silted up, which again allowed access onto the pond for sampling. To minimise the ammount of disturbance to the material recovered, two adjacent holes, around 0.5m apart, were used to recover the alternate half-metre sections of a core. Once recovered the core sections were placed in appropriately labelled casings (longitudinally split plastic piping). These were wrapped in clean polythene sheeting, to help prevent any contamination, before transportation to the laboratory.

Mor-humus/soil material was recovered in the following manner: a trench was dug into the soil, one face of which was then cleaned. Into this face a metal 'monolith tin' was inserted. Carefully, the soil monolith encased by the tin was removed from the adjacent sediments and then carefully padded and packed in clean polythene ready for transportation.

Once back from the field the cores and monolith were stored in a cold room at a temperature of 4°C, to minimise evaporation and microbial activity, before processing.

3.2 Laboratory Work.

3.2.1 Pollen Extraction.

In the laboratory, after unwrapping, to remove surface contamination inevitable in the field, the cores were cleaned of superficial material with a clean scalpel. The stratigraphy of the cores was noted, and the cores were then subsampled in the following manner. Portions, of sediment roughly $1cm^3$ in volume, were cut from the centre of the core, with the sampling interval of either 8, 4, 2, 1 or 1/2 cm (the interval varying with the amount of detail wanted from a particular core). The individual samples were cut in such a way that they occupied 1cm (or 1/2cm if appropriate) depth of the core.

Similarly the mor humus/soil monolith, after cleaning as well as possible,was sliced every 1.5cm using a metal plate as a cutting tool. Each portion was placed into a plastic bag then thoroughly mixed to lessen the effect of any remaining contamination before a sample of roughly $1cm^3$ was taken for further treatment.

The samples were then treated to concentrate the pollen contained within them using the standard methods outlined below (a more detailed programme for these procedures is given in Moore and Webb (1978)):

A. KOH digestion- samples boiled for 15-20 minutes in 10%

potassium hydroxide to deflocculate and remove humic colloids.

B. HF treatment- samples boiled in concentrated (40%) hydrofluoric acid for 10 minutes, or longer if necessary, to remove siliceous material.

C. Acetylation - samples boiled in a mixture of 90% acetic anhydride, 10% concentrated sulphuric acid for between 2-5 minutes to remove cellulose.

Additionally, in samples containing calcium carbonate, a treatment of 10% hydrochloric acid was applied before stage 2. Samples rich in clay were treated with sodium pyrophosphate, again before stage 2, to deflocculate and remove it (see Bates et al.,1978).

Once a concentrated pollen pellet had been obtained from each sample, it was stained with aqueous safranine and dispersed in glycerol jelly ready for mounting on microscope slides.

3.2.2 Counting.

At least two slides were made up from the jelly obtained from each sample, and a minimum of 250 grains were counted on each slide. In some cases pollen types assumed to be of local origin, such as Cyperaceae, *Alnus* and *Calluna vulgaris*, if very numerous, were excluded from this total and noted separately. Information on when this was done will be given in the relevant chapters. The pollen grains were counted using a Zeiss binocular phase contrast microscope with a mechanical stage. A magnification of x400 was used as standard, x1000 being used in the identification of difficult taxa.

The pollen grains were identified using the pollen and spore keys in Moore and Webb (1978), Faegri and Iversen (1974), unpublished keys by Moore and with refrerence to 'type slides' of known taxa. Pollen grains that were unidentifiable due to bad corrosion, severe crumpling or were badly obscured were not taken into account.

3.3 Radiocarbon Dating.

A number of sediment samples were selected for ^{14}C dating so that a better understanding of the time periods covered by the relevant pollen diagrams could be obtained. In the case of peat and lake cores the samples to be analysed were cut from the sediment sections, and after the removal of any obvious contamination, were packaged in clean plastic bags. Two samples were also selected from the mor humus/soil monolith. These samples were made up of the relevant material obtained when the monolith was sectioned, that had been stored in clean plastic bags. Without any other pretreatment the samples were sent to the Scientific Services Radiocarbon Laboratory at the Scottish Universities Research and Reactor Centre, East Kilbride where they had been accepted for analysis (^{14}C Dating Allocation No. 363/0188).

Once they had been analysed, the results were published in Radiocarbon. Details of the samples selected and the results obtained from them are given in the relevant chapters. The results are expressed relative to the conventional radiocarbon timescale and at the ± 1σ level for overall analytical confidence. The older dates obtained are expressed as the number of years before present (B.P.), it should be noted however, that the reference datum for this timescale (i.e. 0 years B.P.) is AD 1950.

A problem that affects this study is that within the last 250 years or so the timescale is blurred by the effects of fossil CO_2 emissions, therefore samples recording ^{14}C ages of ≤250 years B.P. are liable to be ambiguous. It is therefore common practice to classify such material as 'modern' (Harkness et al., 1986).

3.4 Numerical Analysis.

As an aid to the interpretation of the results from the pollen studies a number of numerical analysis were carried out using the DECORANA and ZONATION computer programs. Both programs are written in FORTRAN and were run on a Digital Equipment Corporation VAX/VMS mini-computer at the computer centre, Kensington Campus, Kings College London. In the case of both programs only the pollen types present at values of 2% total pollen, in at least two samples, from each core were used in the analyses. Pollen types present at values below this figure have little effect on the overall results of the analyses (H.J.B. Birks, pers. comm.). A description of these programs is given below:

3.4.1 DECORANA.

The DECORANA program allows one to analyse a data set using a multivariate statistical technique known as detrended correspondence analysis. The technique and program were developed by Hill (1979). The method is a derivation of a technique of ordination known as reciprocal averaging or correspondence analysis (Hill, 1974; Birks and Gordon, 1985). A major problem of correspondence analysis is that there is a tendency for the second axis of variation to have a strong quadratic relationship to the first axis, producing an 'arch' effect (Gauch, Wittaker and Wentworth, 1977). Detrended correspondence analysis avoids this by demanding that there should be no systematic relationship of any kind between the higher axes and the first.

In this study only the results of the first two axes of variation are given. They are usually given in the form of the axes 1 and 2 scores of the samples (or species) being plotted against each other.

3.4.2 ZONATION.

The ZONATION program (a listing of this program is given in Birks and Gordon, 1985), as its title implies, mathematically divides pollen diagrams into assemblage zones using three different techniques: binary divisive analysis using information content criteria (SPLITINF), binary divisive analysis, using sum of square criteria

(SPLITLSQ) and constrained single-link analysis of the data (CONSLINK). Birks and Gordon (1985) give the mathematical background to these techniques. The results are presented in the manner suggested by Birks (in Berglund, 1979).

CHAPTER 4 - BURTON MILL POND.

4.1 Site Description.

This site, map reference SU 977 178, lies on a low east-west ridge of the Folkestone Beds division of the Lower Greensand, about 3km south of Petworth. The Mill Pond itself has an area of 12.4 hectares. It is stream fed mainly with water from springs rising at the base of the South Downs, open-water pH readings of between 7 and 8 reflect the influence of a calcareous source for much of the water. Chingford Pond, a body of water of a similar size to the Mill Pond is shown on many as lying immediately to the south of the Mill Pond. However it appears to have now largely silted up. Fig. 4.1 provides a geological sketch map of the area.

A village called Burton is mentioned in the Domsday book, this is of note as a mill and a fishery are mentioned in the inventory for this village. In the seventeenth century a forge used in the regional iron industry was sited here (Straker, 1931), it is known to have been working in 1667 but it had ceased production before 1724. It is thought that this site was used because of the good water supply available, as this forge was some distance from the nearest furnace.

Much of the pond is surrounded by the Burton Pond Local Nature Reserve including areas of land notified as

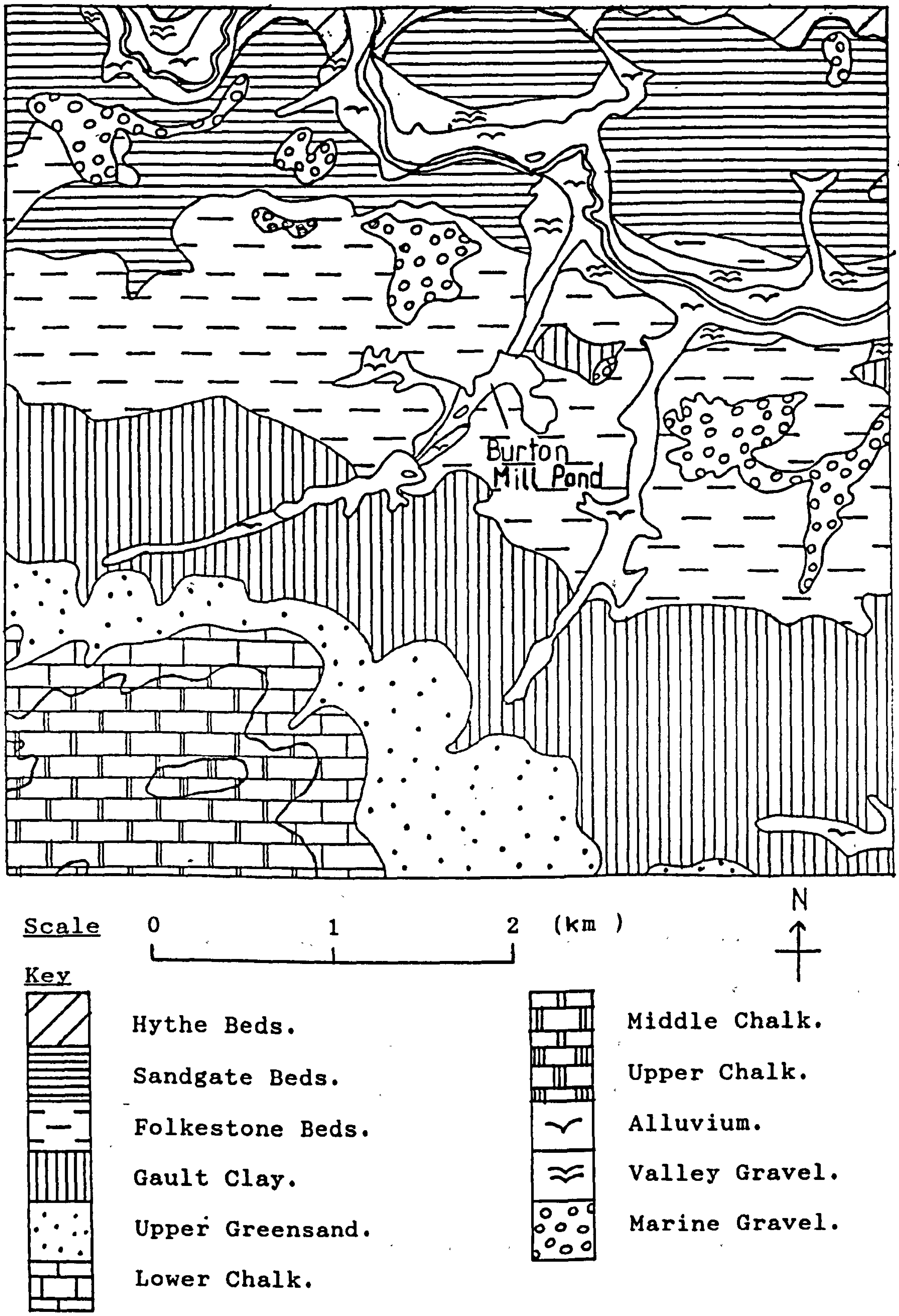


Fig. 4.1 Burton Mill Pond - geological sketch map.

Sites of Special Scientific Interest. A number of different vegetation types associated with different soils are present in the reserve. This allowed the pollen record from the lake sediments to be compared with the results of pollen studies from a number of local terrestrial deposits. In all a total of 5 cores were taken from this site. Fig. 4.2 gives a map showing the extent of the Nature Reserve together with the positions that the cores used in the study of this site were taken.

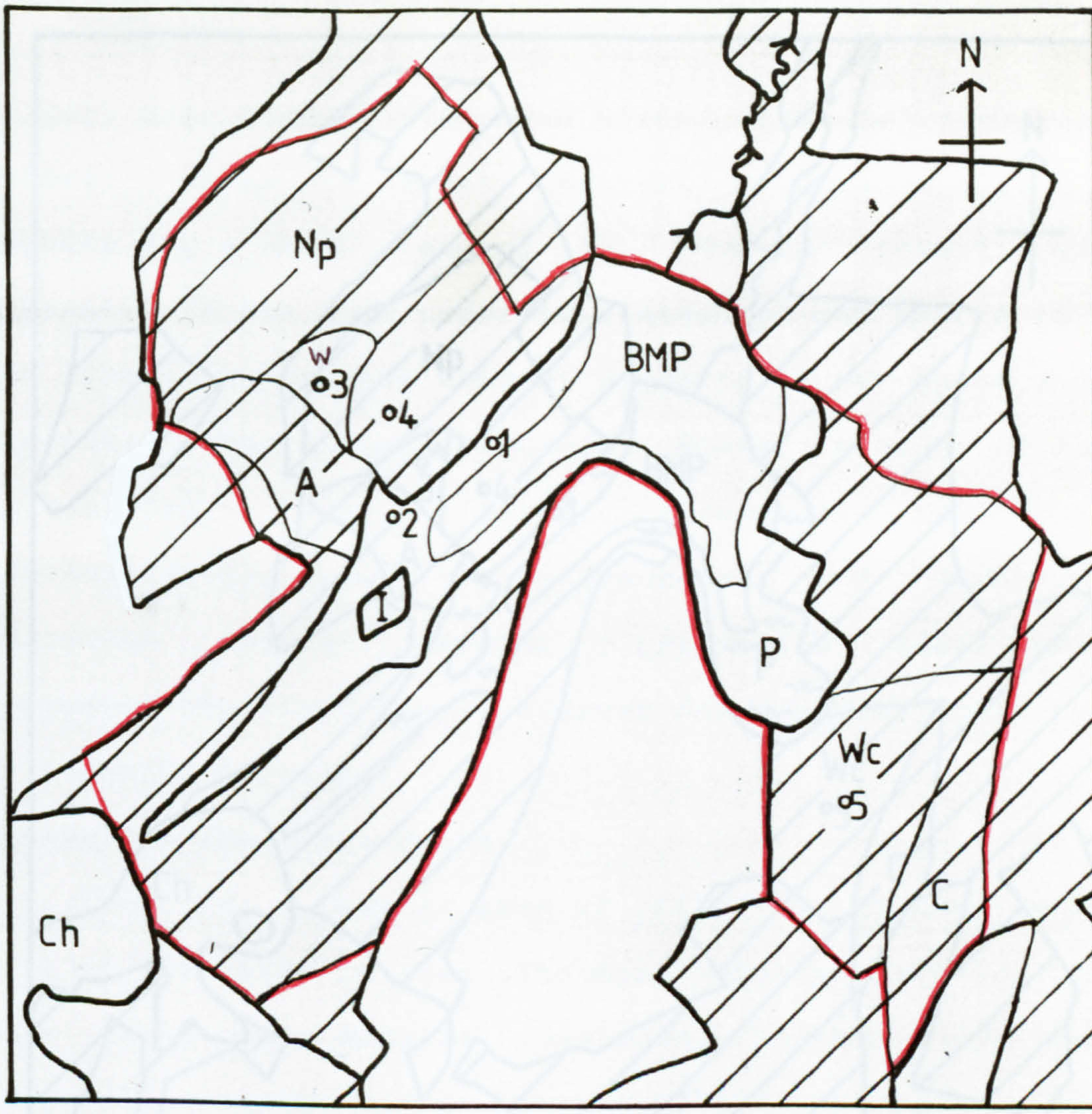
The vegetation of the areas making up the nature reserve is briefly described in the following:

A/Pond Margins

This transitional zone between open water and dry land consists of reed beds made up of: common reed, (*Phragmites australis*); branched bur-reed, (*Sparganium erectum*) and the common reedmace, (*Typha latifolia*), together with the sedges: greater pond sedge, (*Carex riparia*) and greater tussock sedge, (*Carex paniculata*). It should be noted that at some points the drier fringes of the reed beds are developing into alder carr. Cores 1 and 2, representing the pond's sedimentary record were taken from this, undisturbed area. It was not possible to take a core from the main body of the Mill Pond as it had been recently dredged by the local County Council.

B/Newpiece Wood

This area slopes upwards towards the west, and is



Scale 0 0.5 (km)

Key.

Wooded area. Limits of Reserve

BMP - Burton Mill Pond. P - Pond Margins.

Np - New Piece. Wc - Welch's Common.

W - New Piece, Wet Heath. C - Crouch's Common.

A - New Piece, Alder Wood. Ch - Chingford Pond.

1-5 - Positions of cores BMP1-5 respectively.

Fig 4.2 Burton Mill Pond - Map of Site.

largely dominated by even-aged birch (*Betula pendula*). However, areas of sweet chestnut (*Castanea sativa*), coppice and a small stand of oak (*Quercus robur*), are present. It was from under this stand of oak that core 4 was taken, as here the deepest deposits of mor humus were present. Other trees include Scots pine (*Pinus sylvestris*), rowan (*Sorbus aucuparia*), whitebeam (*Sorbus aria*), yew (*Taxus baccata*) and hornbeam, (*Carpinus betula*). Bracken (*Pteridium aquilinum*), dominates the field layer, however *Rhododendron ponticum* is becoming important.

C/Newpiece Wood- Wet Heath

This is a small area of valley bog in the lowest part of the Newpiece area. The most important species in this area are *Molinia caerulea*, heather (*Calluna vulgaris*), cross-leaved heath (*Erica tetralix*) and *Sphagnum* spp.. There is some invasion of birch, pine and bracken, and the numerous tree stumps remaining on the bog suface, provide evidence of past woodland. It was from the peat present in this area that core 3 was taken.

D/Newpiece Moor- Alder Wood

This is a mature, if not overmature, even-aged alder carr. However it does show signs of being coppiced in the past. Alder buckthorn (*Frangula alnus*), is present as a shrub while tussock sedge (*Carex paniculata*), is the dominant species in the field layer.

E/The Island

This small area is covered with birch and alder with a dense understory of rhododendron.

F/Welsh's Common- Black Hole

This area can be split between an area dominated by alder and sallow (*Salix caprea*) carr, together with a transitional area covered largely with *Calluna vulgaris* but also containing more interesting species such as bogbean (*Menyanthes trifoliata*), and cranberry (*Vaccinium oxycoccus*). It was from the peat present in this transitional area that core BMP5 was taken.

G/Welch's Common and Crouch Common- Dry Birch Heath

This area is mainly covered by bracken, scattered birch trees, with a small area of oak and yew woodland on the western side.

The rest of the area surrounding the pond consists of a mosaic of farmland, plus areas of both deciduous and coniferous woodland, scrub and some residential dwellings.

4.2 Burton Mill Pond Core 1 (BMP1).

This core was taken from the margins of an area of reed swamp on the north-west edge of the Mill Pond (see Fig. 4.2)

4.2.1 Stratigraphy.

The total depth of sediments at this site is 4 metres, this core consisting of the bottom 2 metres of the sediments. Unfortunately the top 2 metres of these sediments could not be collected using a Russian borer as they were too fluid. The lithology of the sediments is as follows:

200-216cm Reed-swamp peat.

216-244cm Silt.

244-263cm Silty mud.

263-334cm Silty mud, less organic matter.

334-338cm Organic rich mud.

338-363cm Silt, some organic matter.

363-367cm Silt, organic-rich.

367-377cm Compacted peat with ericaceous roots.

377-390cm Organic-rich sand with roots.

4.2.2 Pollen Stratigraphy.

This core was sub-sampled evey 8cm to the depth of 344cm, after which point it was sub-sampled every 4cm. At least 500 pollen grains were counted for every level, including at least 100 arboreal pollen grains (excluding *Alnus glutinosa*). Fig. 4.3 gives a summary diagram for this core where the results are expressed as percentages of total pollen and spores (T.P.). However, because of the high numbers of the *Alnus, Calluna* and Cyperaceae pollen types, an amended sum of pollen and spores (S.P.) was used in constructing the main pollen diagram for this core (Fig. 4.4), where *Alnus, Calluna* and Cyperaceae are excluded from the total. It should be noted that in Fig.4.4 *Alnus, Calluna* and Cyperaceae are expressed as percentages of total pollen and spores (T.P.). Those pollen types recorded from this core that are not included in the main pollen diagram are shown in Table 4.1.

When discussing the results, it is often necessary to express all of them in the form of percentages of total pollen and spores (T.P.), then facilitating comparison with data from other workers.

4.2.3 Numerical Analysis.

Due to the high values of *Alnus, Calluna vulgaris* and Cyperaceae, DECORANA and the zonation programs were run twice, once with these taxa included and once with them excluded. The pollen types used in these runs were:

Run 1- *Betula, Alnus, Fagus, Quercus, Corylus, Salix, Calluna vulgaris, Erica, Ranunculus acris* type,

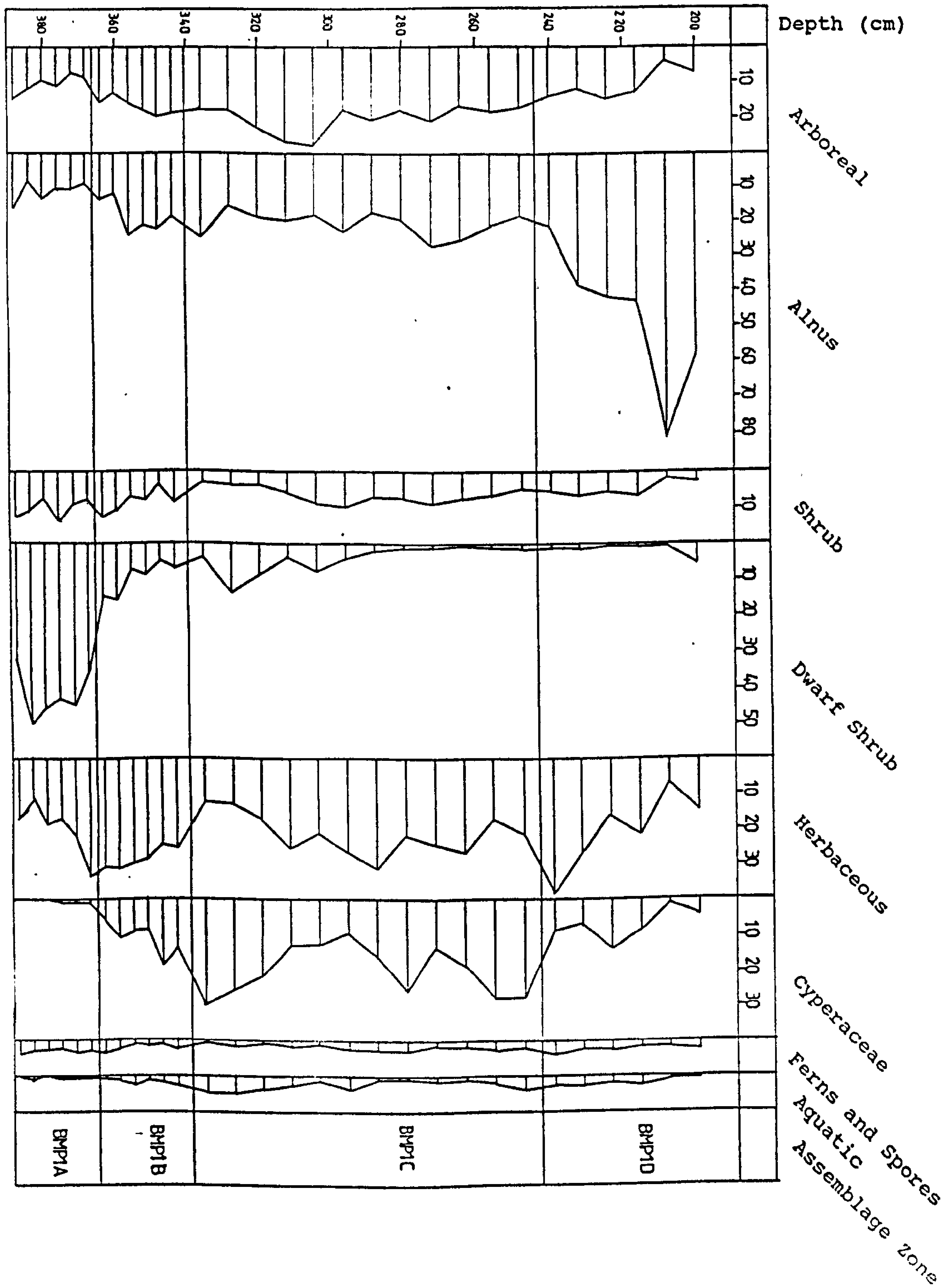


Fig. 4.3 BMP1 - Summary Pollen Diagram

(Values expressed as percentages of sum of total pollen and spores.)

Fig. 4.4 BMP1 - Main Pollen Diagram.
All values, except Alnus, Calluna vulgaris and Cyperaceae, are expressed as percentages of the ammended pollen sum. The values of Alnus, Calluna vulgaris and Cyperaceae are expressed as percentages of the total sum of pollen and spores.(+ represents values <1%)

Fig. 4.4 Cont.

Erica
Calluna vulgaris
Anemone
Ranunculus acris type
Cruciferae
Hypericum perforatum type
Caryophyllaceae
Chenopodiaceae
Ononis type
Trifolium type
Lotus type
Vicia sylvatica type
Chrysosplenium
Rosaceae undiff.
Filipendula
Rubus
Potentilla type
Geum
Umbelliferae
Mercurialis
Polygonum aviculare
Rumex acetosella
Rumex acetosa
Rumex obtusifolius type
Fagopyrum type
Urtica type
Cannabis type
Lysimachia vulgaris
Solanum dulcamara
Melampyrum
Stachys type
Teucrium
Plantago media/major type
Plantago lanceolata
Campanula type
Galium type
Bidens type
Carduus
Aster type
Anthemis type
Artemisia
5
10 20 30 40 50
10

Fig. 4.4 Cont.

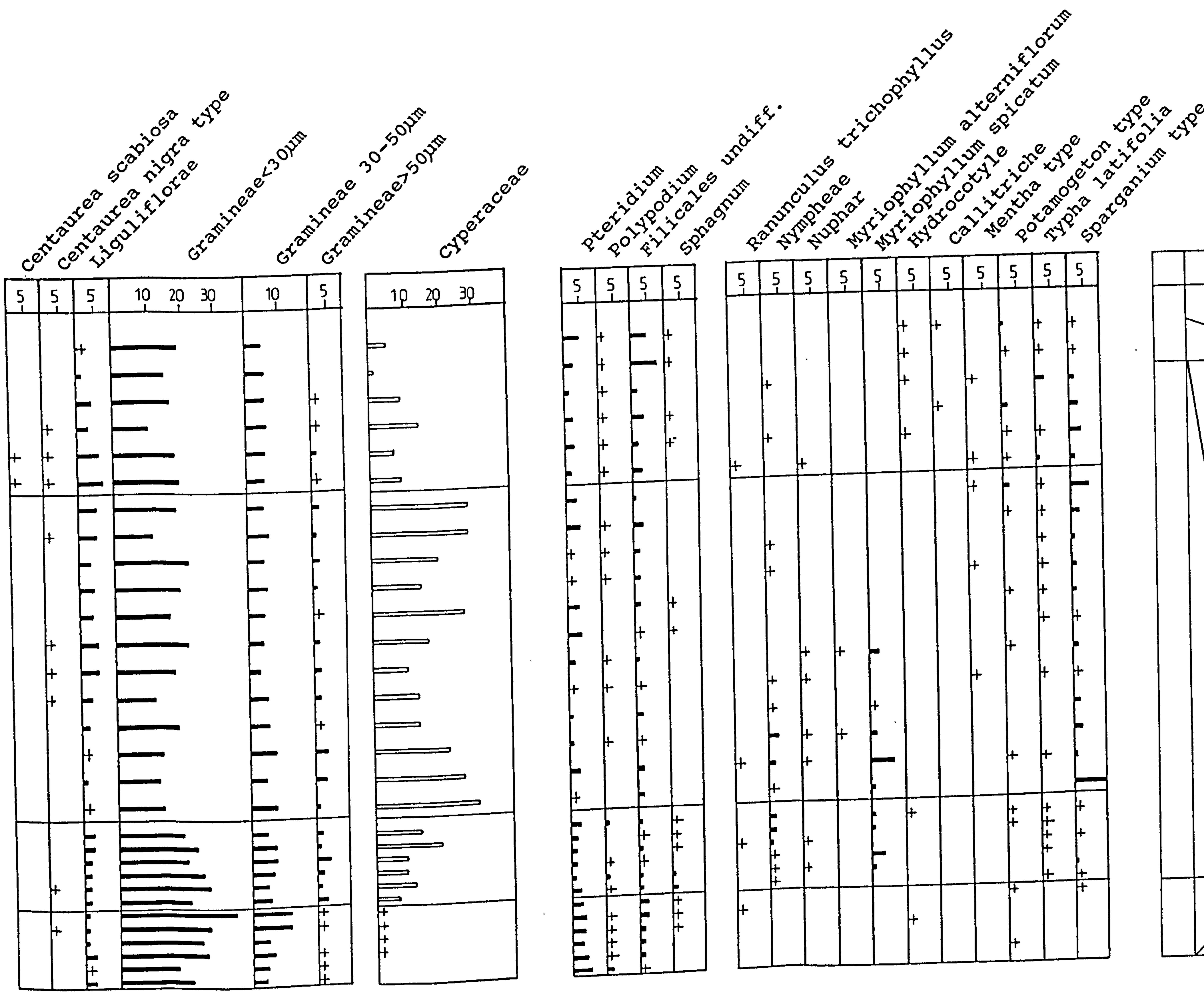


Fig. 4.6 BMP1 Results of Run 1 of the Zonation program.

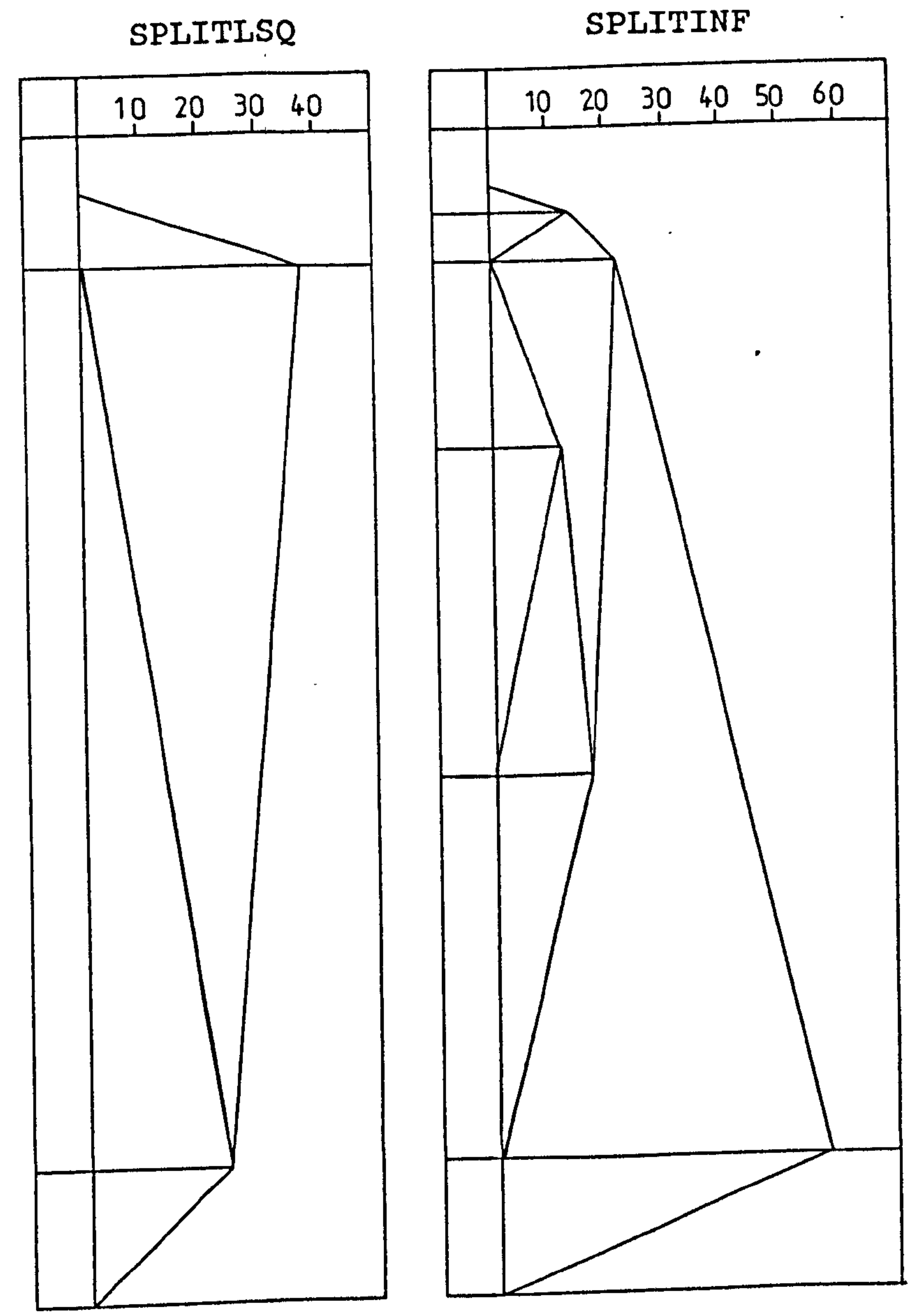


Fig. 4.6 Cont.

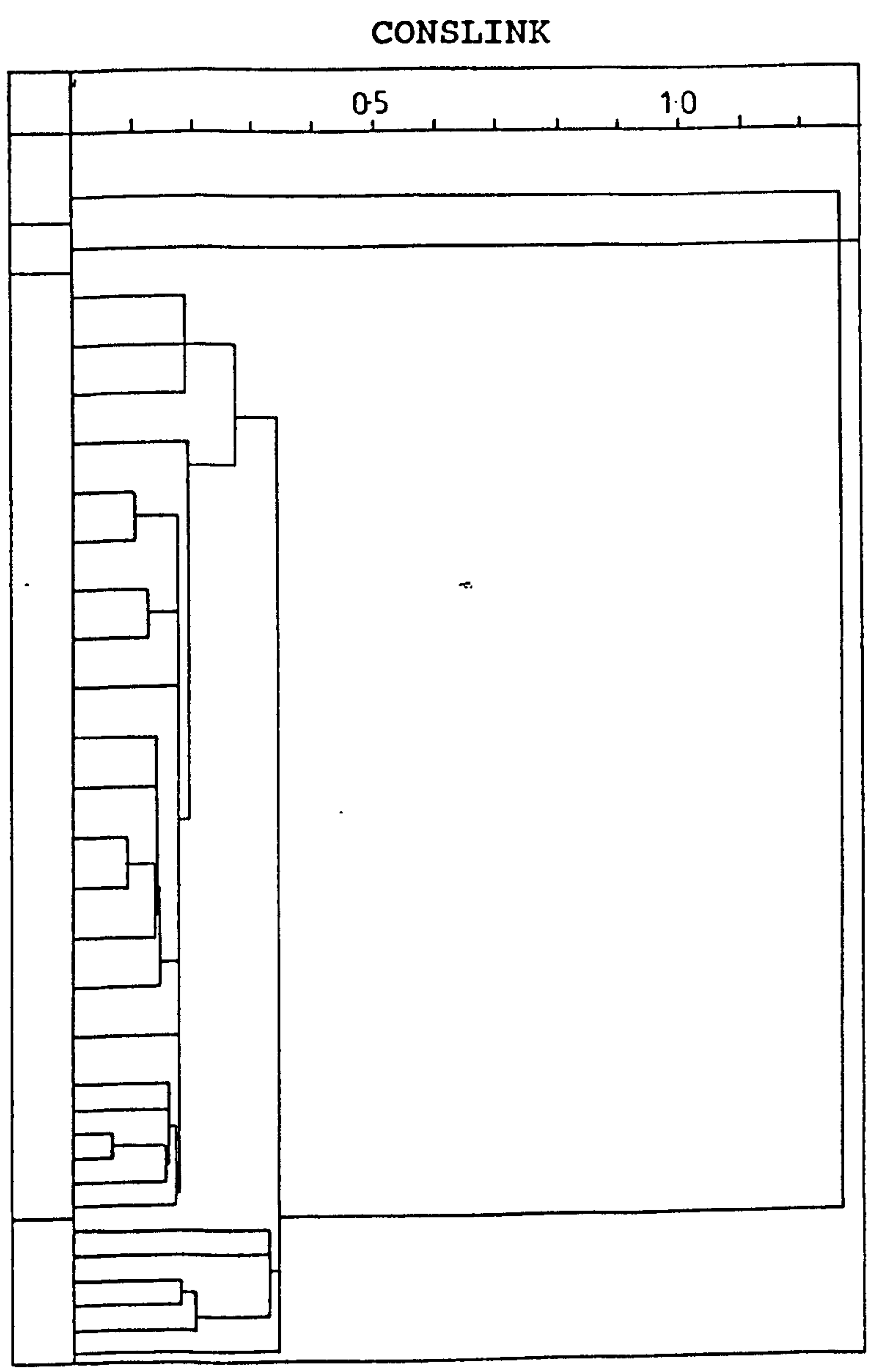
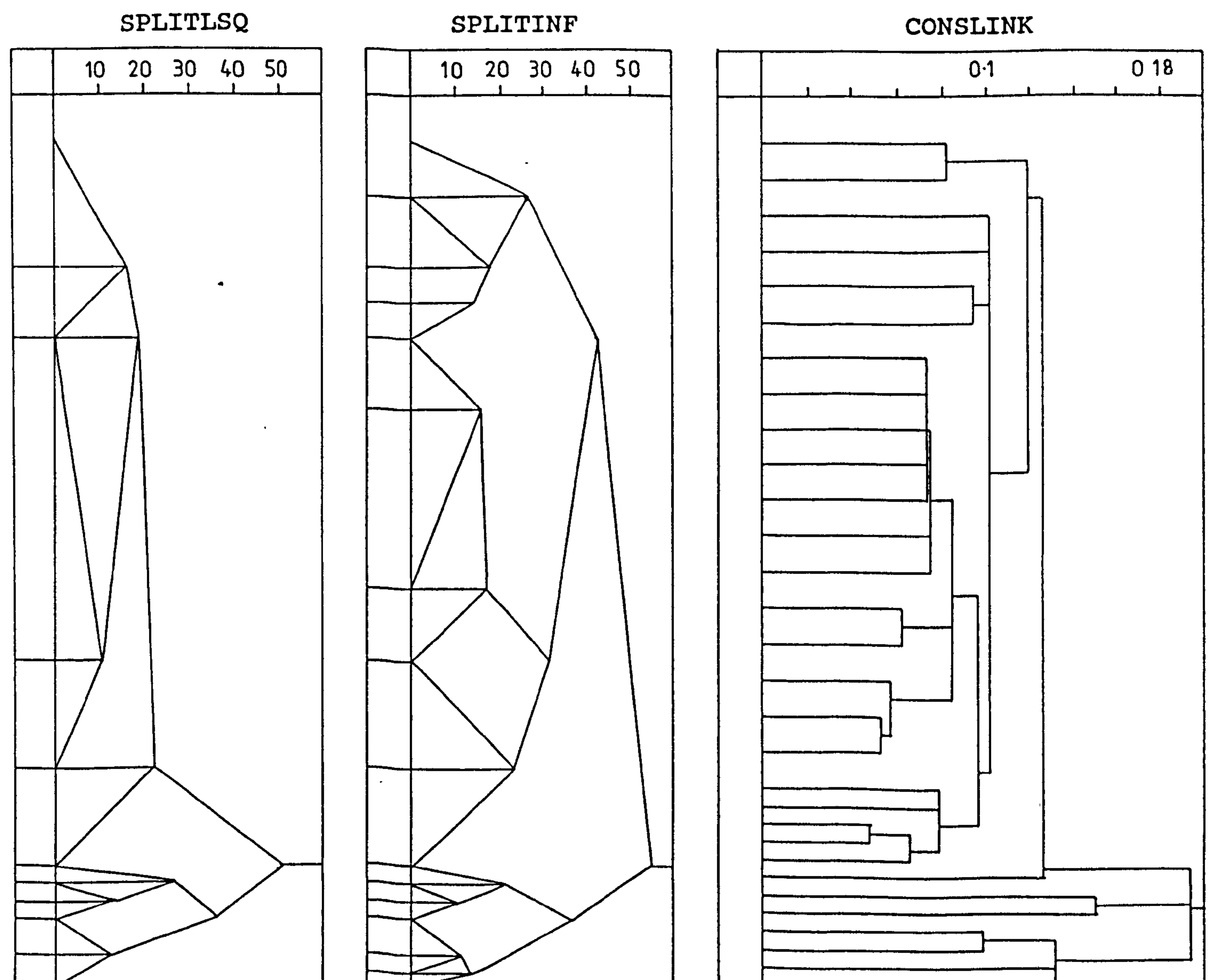


Fig. 4.8 BMP1 Results of Run 2 of the Zonation program.



DEPTH (cm)	POLLEN TYPE
208-209	*Hippophäe, Lythrum portula*
232-233	*Parietaria judaica, Scrophularia type, Lamium* type
240-241	*Fallopia convolvulus* type
264-265	*Cynoglossum*
280-281	*Viburnum, Digitalis, Veronica*
288-289	*Lathyrus*
312-313	*Papaver, Solanum nigrum*
328-329	*Sanguisorba minor* (x2)
344-345	*Valeriana dioica*
348-349	*Juglans*
356-357	*Frankenia* (x2), *Lycopodium clavatum*
368-369	*Caltha* type, Leguminosae undiff.
372-373	*Succisa pratensis*
376-377	*Geranium* type
388-389	*Agrimonia*

Table 4.1 Pollen types found in BMP1 not included in the main pollen diagram.

Filipendula, Umbelliferae, *Rumex acetosa* type, *Plantago lanceolata*, Liguliflorae, Cyperaceae, Gramineae, *Pteridium* and Filicales.

Run 2- *Betula, Fagus, Quercus, Corylus, Salix, Ranunculus acris* type, Cruciferae, *Filipendula, Potentilla*, Umbelliferae, *Rumex acetosa, Plantago lanceolata*, Liguliflorae, Gramineae, *Pteridium* and Filicales.

The results are shown in Figs. 4.5 to 4.8.

4.2.4 Local Pollen Assemblage Zone Descriptions:

Zone BMP1A. Depth 390-367cm

The upper boundary of this zone, between samples 25 and 24, is shown to be significant by all of the zonation programs in Run 1, but in Run 2 of the programs the split between 24 and 23 is seen to be more important. Many significant divisions are also seen within this zone, however. These are best interpreted as reflecting the fluctuations in the taxa included in this run, the importance of which will be exaggerated due to the absence of *Calluna* pollen from the data set.

The samples making up this zone are seen to form a close, discrete cluster in Run 1 of DECORANA, associated with high axis 1 scores. In Run 2 of DECORANA, however, the cluster is more diffuse, associated with low axis 1 scores, showing some overlap with the members of zone BMP1B.

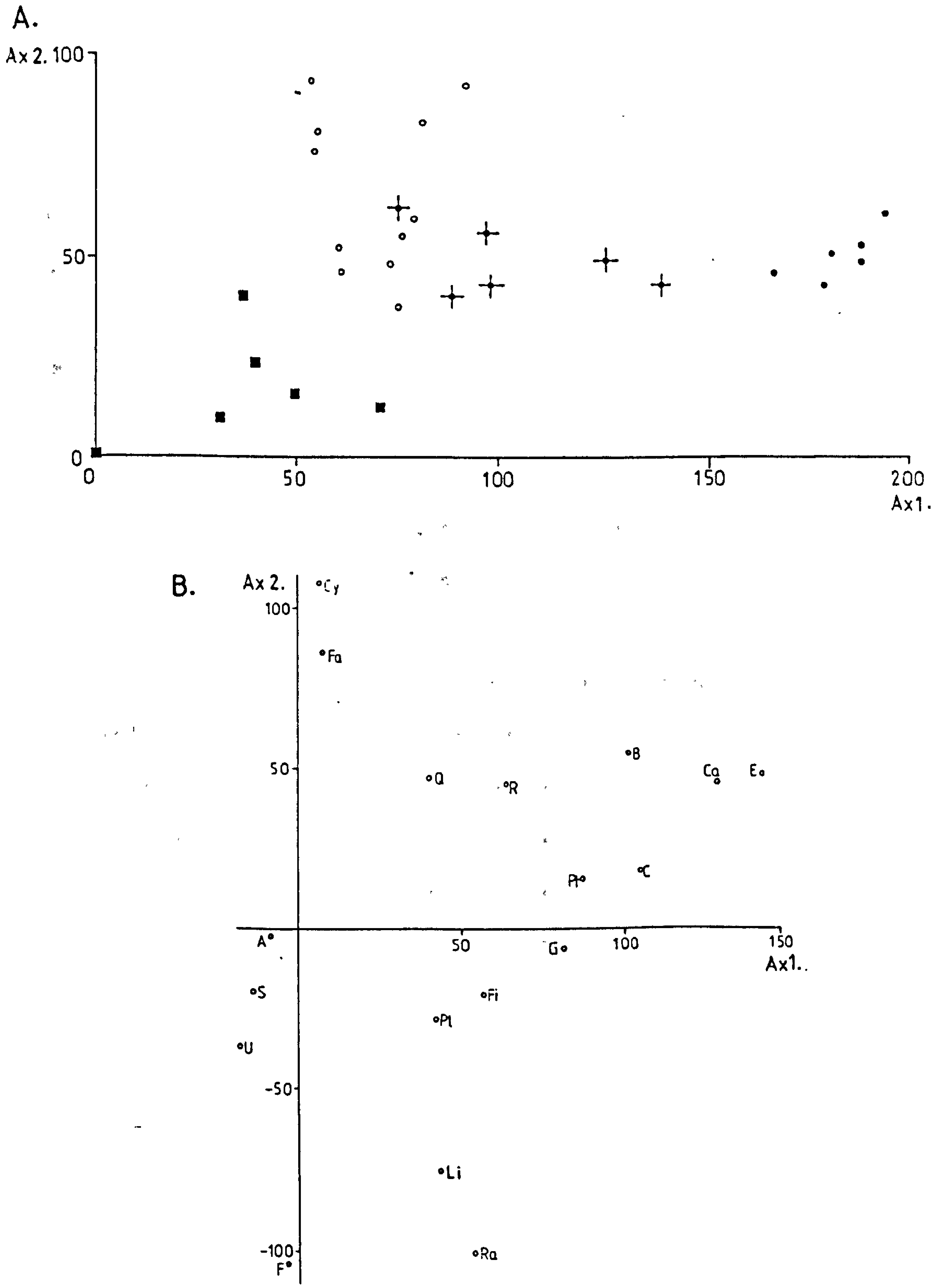


Fig. 4.5 BMP1-DECORANA Run1 A-samples B-Species.

(Key overleaf.)

Fig. 4.5 (cont.)

Key

A: Samples.

● Assemblage zone BMP1A.

-ф- Assemblage zone BMP1B.

o Assemblage zone BMP1C.

■ Assemblage zone BMP1D.

B: Species.

A	- Alnus	Ra	- Ranunculus acris type
B	- Betula	R	- Rumex acetosa type
Q	- Quercus	F	- Filipendula
Fa	- Fagus	Pl	- Plantago lanceolata
S	- Salix	L	- Liguliflorae
C	- Corylus	Cy	- Cyperaceae
Ca	- Calluna	G	- Gramineae
E	- Erica	Pt	- Pteridium
U	- Umbelliferae	Fi	- Filicales

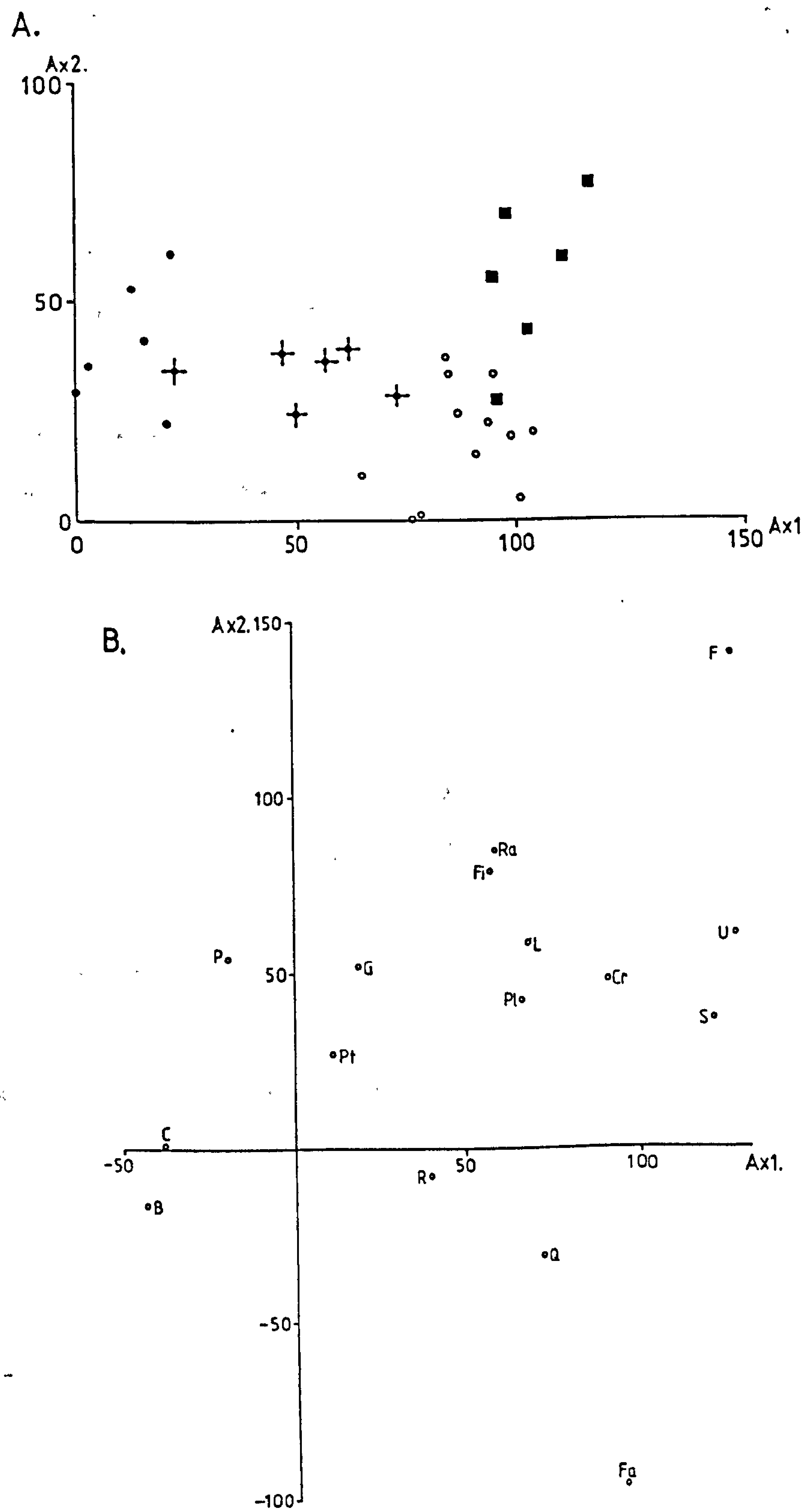


Fig. 4.7 BMP1-DECORANA Run2 A-Samples B-Species

(Key overleaf.)

Fig. 4.7 (cont.)

Key

A: Samples.

- ● Assemblage zone BMP1A.
- -φ- Assemblage zone BMP1B.
- o Assemblage zone BMP1C.
- ■ Assemblage zone BMP1D.

B: Species.

B - Betula	Ra- Ranunculus acris type
Q - Quercus	F - Filipendula
Fa- Fagus	Pl- Plantago lanceolata
S - Salix	L - Liguliflorae
C - Corylus	R - Rumex acetosa
Cr- Cruciferae	G - Gramineae
P - Potentilla	Pt- Pteridium
U - Umbelliferae	Fi- Filicales

This zone is dominated by *Calluna vulgaris*, which fluctuates between 32% and 50% total pollen (T.P.), it averages 41% T.P. in the zone as a whole. Gramineae, is the next most important pollen type, it increases slightly through the zone reaching 48% of the amended pollen sum (S.P.). Throughout the zone as a whole it averages 33% S.P.. *Corylus*, averaging 22.5% S.P., is relatively stable through the zone as is *Betula*, averaging 9.5% S.P.. *Quercus*, averaging 10% S.P., does show a peak of 21% S.P. in sample 29 but this isolated fluctuation is not regarded as significant. *Alnus* is also stable at about 12% T.P..

Zone BMP1B. Depth 367-340cm

The upper boundary of this zone is not considered significant by any of the zonation programs in Run 1. Obviously in this run the influence of *Alnus*, Cyperaceae and *Calluna* is very strong. CONSLINK, however, does show the samples of this zone as being closely linked. In Run 2 of the zonation programs the upper boundary of this zone, between samples 18 and 19, is shown to be significant by all of the analyses. But as mentioned previously, sample 24 is split away from the rest of the zone members, a fact difficult to explain. The DECORANA plots from both Runs 1 and 2 can be interpreted as showing the intermediary nature of this zone, linking zones BMP1A and BMP1C. In fact there is some degree of overlap between zones BMP1B and BMP1C in Run 1, and of zones BMP1A and BMP1B in Run 2.

The most striking feature of this pollen assemblage zone is that *Calluna* initially drops sharply to 15% T.P. and continues to fall to less than 10% T.P. by the top of this zone. *Corylus* also shows a marked downward trend throughout, falling from a value of 19% S.P. at the beginning of the zone to 6% S.P. near the top. *Alnus* and *Quercus*, however, both increase, *Alnus* from around 13% T.P. to values around 20% T.P. and *Quercus* from 10% S.P. to over 20% S.P. near the end. *Betula*, however, remains stable, changing little from the previous zone to average 8.5% S.P. in this zone. Cyperaceae shows a marked increase, rising to values of 19% T.P. and 13% T.P. in the upper samples. Gramineae is little changed in this zone, it remains stable, averaging 31% S.P.. The amounts of herbaceous pollen generally increase (in the emended pollen sum), as does the number of herbaceous taxa recorded.

There is a general increase of the aquatic pollen types in this zone.

Zone BMP1C. Depth 340-244cm

The mathematical significance of the split between samples 6 and 7 can be clearly seen in all the results from Run 2, and it is also seen to be important by SPLITINF in Run 1, but this is probably simply a reflection of the fall in the frequency of Cyperaceae seen in sample 6. The DECORANA plots show the members of this group as a relatively discrete cluster in both runs. However, this is more apparent in the results from Run 2, the results from Run 1 show a higher degree of variation within the zone, but comparison with the DECORANA species plots for this run suggests that this variation can be attributed to the influence of Cyperaceae on tha axis 2 scores.

Cyperaceae is numerically important, but fluctuates markedly throughout the zone. *Alnus* and *Quercus* are relatively steady throughout the zone, averaging 21% T.P. and 27% S.P. respectively. *Calluna* is more abundant in the lower half of the zone averaging 7% T.P., while in the upper half it does not rise above 2% T.P.. *Corylus* and Gramineae are relatively stable, averaging 7% S.P. and 23% S.P. respectively. *Betula* falls in the first half of the zone, but then stablises. *Fagus* is at its most important in this zone, fluctuating between 2% and 10% S.P.. *Salix* increases in importance.

Zone BMP1D. Depth 244-200cm

The divisions within this zone, seen in the results of Run 1 of the programs can be assigned to the variations in the values of *Alnus*. The similar divisions in Run 2 of the programs are however difficult to explain. The results of DECORANA Run 1 clearly show the samples making up this zone as a distinct cluster, its low axis 1 and 2 scores are clearly influenced by the high *Alnus* content of these samples. The variation within the group is due to the differences in the numbers of *Alnus*. In Run 2 we also see a relatively close grouping, with some overlap with zone BMP1C.

This zone is dominated by *Alnus*, which shows a great degree of variation, rising dramatically in the uppermost samples. Cyperaceae values drop during this zone and are much less variable. They average 17.5% S.P. during the zone as a whole. Gramineae, *Quercus*, *Corylus*, *Fagus*, *Betula* and *Salix* have changed little from the previous zone. The high numbers of *Filipendula* are noteworthy, reaching a peak of 12% S.P.. *Calluna* also shows a peak, of 21% S.P. in the last sample.

4.2.5 ^{14}C Analysis.

Three samples were selected for ^{14}C analysis from this core, these were:

1. SRR-3411 This sample was made up of the peat from the depth of 367-377cm below the present surface. The results of the ^{14}C analysis gave the age of the sample as being 630 ± 65 years before present (B.P.).
2. SRR-3410 This sample consisted of the lake muds from depth 245-255cm below the present surface. It gave a date

of 320 ± 65 years B.P..

3. SRR-3409 Taken from the reed samp peats from 200-210cm below the present surface, this sample gave a 'modern' date (120 ± 65 years B.P.).

The position and dates of these samples are also shown on the main pollen diagram (Fig. 4.4).

4.2.6 Local Pollen Assemblage Zone Interpretations:

Zone BMP1A.

The upper boundary of this pollen assemblage zone is coincidental with the point in the sediments where the peat and sands at the bottom of the core are replaced by lake sediments. Therefore it is reasonable to assume that the sediments making up this zone consist of the former soil, flooded and subsequently sealed by sediment deposition when the pond was constructed. Evidence from the ^{14}C analysis of sediments from the upper part of this zone suggest that, within the 1σ confidence limit, the peat dates from between AD 1255 and 1385. This means the Mill Pond is very unlikely to have been built before this period. This pollen assemblage zone therefore represents the vegetation present upto this time.

The nature of the soil and its pollen content suggests it is the mor humus and A horizon of a podzolic soil, from under a *Calluna* dominated heath similar to those present on many areas of the Folkestone Beds today.

The high numbers of *Calluna* pollen in this assemblage zone, and the presence of ericaceous roots in the sediments also show that heathland was present at this site. The fact that Gramineae pollen is the second most important component in this assemblage zone, and that significant ammounts of *Erica* and *Pteridium* are present plus records of *Campanula* and *Genista* (a type which includes *Ulex* and *Cytisus*) all help to confirm that heathland conditions are represented by this assemblage. Comparison with surface pollen studies in the north of England by Evans and Moore (1985) show that the averages of 41% T.P. *Calluna* and 16% T.P. Gramineae pollen present in this zone fall within the range found on the moorland studied. The *Calluna* pollen data from this zone suggests that the immediate area of the sampling site had an incomplete cover of *Calluna vulgaris*. It is possible that *Erica* spp. are a co-dominant in the immediate area, since pollen production by *Erica* is much lower than that of *Calluna* (this is due to the pollination strategy of *Calluna* involves an anemophilous component as well as an entomophilous one, while *Erica* relies almost exclusively on entomophilous dispersal). It is also likely that areas of *Pteridium* and grasses were a part of the heathland mosaic.

The relative importance of *Plantago lanceolata* in the herbaceous pollen spectrum suggests that there is a degree of pastoral agriculture in the area. *P.lanceolata* is a species that is not normally found on heaths on dry sandy soils, but has high pollen dispersal capacities (Behre, 1981), so this pastoral element is not likely to be present in the immediate area of the sampling site. The presence of pollen of *Rumex acetosa*, *Ranunculus acris* type and Liguliflorae add evidence of pastoral agriculture (Behre, 1981).

The work of Tinsley and Smith (1974), who studied pollen deposition along transects crossing a woodland/heath transition, is of particular use when considering the arboreal pollen data. They found that deposition of *Alnus* pollen on heathland can be rather erratic, and suggest that individual peaks of *Alnus* pollen of upto 21% may have little significance in terms of the sampling site's immediate vegetation. However, in this assemblage zone the fact that *Alnus* is consistently important suggests that it was present locally, most probably along the stream in the valley bottom. This, together with the consistent records of *Filipendula* and records of *Caltha* and *Succisa* pollen add weight to the hypothesis that wet conditions were present locally. The presence of *Filipendula* suggests that conditions here were less acidic than might be expected from the former heathland vegetation, possibly due to the influence of calcareous water from the springs at the base of the South Downs.

This possibility of wet conditions being present in the area, confuses the interpretation of the *Potentilla* pollen present in the zone. Moore, Evans and Chater (1986) point out that the species most likely to be represented by this pollen type are *P. palustris* (a species associated with wet conditions such as poor fen and carr woodland) and *P. erecta* (found in acid conditions such as heathland, and sometimes an indicator of sheep grazing). Either or both of these species could be represented in this assemblage.

As *Quercus* and *Betula* occur in relatively low amounts, comparison with the data produced by Tinsley and Smith (1974), suggests that pollen deposition at the sampling site is not affected by any woodland edge feature. This implies that the sampling site is at least 100m away from the nearest woodland of this type, and that this arboreal pollen is largely derived from a regional source. It is possible that of the *Betula* pollen represents some degree of invasion onto the heathland by this species, but the relatively low amounts of pollen involved would suggest any such successional process is of little importance.

Corylus pollen is more numerous than that of either of these trees. This suggests that either the oak woodland in the region is being managed as coppice and standards, that is standard oak trees are being grown with coppiced underwood consisting of, at least in part, *Corylus*. Alternatively *Corylus* was growing relatively close to the sampling site, suggesting the presence of brown earth soils nearby. However it must be noted that this study was carried out in an area much further south than those of Tinsley and Smith, or Evans and Moore, and the regional background of pollen, particularly of arboreal pollen types may consequently differ significantly.

Zone BMP1B.

The lithostratigraphy of this pollen zone consists of lacustrine sediments. This fact means that there are important differences in pollen recruitment into the sediments, and also changes in the pollen catchment area compared with the previous zone. Moore and Webb (1978) state that the pollen incorporated into lake sediments may have arrived from a number of different sources, the most important being (a) from organisms growing in the lake,(b) input of pollen from the air, (c) pollen from the surrounding region via drainage water and (d) secondarily transported pollen from deposits eroded by drainage water. It should be noted that the drainage that feeds the Mill Pond is from two sources, the component arriving in streams that feed this lake system and the water that arrives directly from overland runoff through the topsoil and over the soil surface. Peck (1973) and Bonny (1976, 1978) estimated that the pollen that arrives in a lake via stream input accounted for between 85% and

97% of the pollen that annually reach the lake sediments. Pennington (1979) however, showed that the amount of pollen reaching lake sediments in this manner depended on the lake's surrounding vegetation, and was smaller (<50% of total pollen input) in lakes with a forested catchment. It should be noted, however, that the studies of Pennington, Bonny and Peck were carried out in lakes of upland northern England. This area has high levels of rainfall, a factor that could be important when comparing these studies with data from other areas. Peck (1973) stated that stream-borne pollen is derived from three main sources: (a) pollen falling directly into the stream from bankside vegetation, (b) pollen derived from bank erosion of pollen-containing sediments and (c) pollen transported into the stream via overland water runoff. Therefore, it is important to consider the areas through which the streams feeding the Mill Pond flow when interpreting the pollen assemblages associated with lake sediments.

The source of the pollen that is deposited into the lake from the air is dependent on the size and radius of the lake. Much work has been done (eg. Janssen, 1966, 1973; Andersen, 1970) which shows that the level of pollen deposition from the air decreases quickly with distance from the source. This implies that a small lake will have a greater input per unit area of pollen from local sources than would a lake of greater radius where some of water surface is beyond the deposition range of much of the local pollen (Jacobson and Bradshaw, 1981; Bonny, 1980). Similarly, following Tauber's (1965) model, a lake of large diameter will receive a larger proportion of regional pollen than would a small lake. This hypothesis is supported by data from air pollen traps positioned on a lake surface (Bonny, 1976). The relatively small size of the Mill Pond and especially its narrow shape suggest that local pollen input from the air will be more important than the regional airborne pollen component.

Once the pollen within a lake has settled onto the suface of the sediments it may be subject to a degree of mixing with pollen previously deposited if the upper layers of the sediments are resuspended by the action of water turbulance, especially in shallow water. This phenomenon has been studied by Davis (1968) who concluded that the resuspension and redeposition of these surface layers of sediment has two major implications. Firstly, redeposition tends to move pollen from shallow water environments to deeper water conditions, thereby reducing the lateral variation in the sediment's pollen assemblage. This has the effect of making a single core more representative of the whole lake basin. Secondly, as each year's pollen input is mixed with that of previous years, the pollen assemblage at any given vertical position in a core is going to be an average of several years' input. This has the effect of reducing variation caused by differences in the intensity of flowering of different species from year to year but it does allow the easy observation of long-term changes in the pollen sequence.

Having enumerated the considerations that must be taken into account in dealing with lake sediments, we can return to the second pollen assemblage zone. The differences between BMP1B and the previous pollen assemblage zone can largely be explained in terms of the differences in the pollen recruitment and in terms of the response of the vegetation to the flooding of the valley and the accompanying changes in local hydrology. The dramatic fall in the numbers of *Calluna* pollen seen in this zone is possibly the most graphic illustration of the changes in pollen recruitment. Instead of the large amounts of very locally produced *Calluna* pollen being directly incorporated into the sediment, as seen in the previous zone, the pollen in this assemblage must have been deposited after first entering the lake waters. Although there is a component of wind dispersal in *Calluna*'s pollination strategy, the numbers of this pollen type that are found to be transported long distances are low (Hyde, 1952). The majority of *Calluna* pollen must have arrived via water transport, either from south of the site via the main stream input, or from a much more local situation via the small stream entering on the western edge of the pond and via surface drainage water. The differences in geology between these two sources suggest that the second of the two possibilities is more likely. This area is on the Lower Greensand (as contrasted with the Gault and Upper Greensand), and there is a likelihood that heathland, or a mixture of *Calluna/Corylus* scrub, was present on this site previously. Comparison with the amounts of *Calluna* pollen found in lakes studied by Bonny (1976), that were surrounded by *Calluna* dominated vegetation, show that the values seen in this assemblage are higher than those found in that study. Although this supports the case for heathland occuring locally, it is possible that a proportion of the *Calluna* present is derived from erosional events associated with the rise in water level, followed by redeposition. Other pollen and spore types present that could also indicate heathland in this assemblage zone include *Erica, Pteridium, Campanula* and *Lycopodium clavatum*.

The rise in *Alnus* pollen is probably due to the development of the alder carr now seen at the site. Likewise the expansion in the values of Cyperaceae pollen and the records of *Typha latifolia* and *Sparganium* most probably represent the establisment of a pond margin community similar to the one seen at the site today. It is possible that *Phragmites* was a part of this swamp community contributing to theGramineae pollen seen in this zone. It is also possible that some of these reed swamp pollen types may have originated from areas of similar vegetation upstream, arriving via the streams feeding the pond. The increase in *Salix* is again likely to be due to its being present around the pond margins. The appearance of submerged and floating aquatic taxa such as *Nymphaea* and *Myriophyllum* suggests that the colonisation of the newly formed open body of water by these aquatic species was relatively rapid.

The other major feature of this zone is the increase in the amounts of arboreal pollen present, this can be seen to be almost totally due to the increases in *Quercus* and *Fagus* pollen. This may be a reflection of the importance of the stream input of pollen into the lake, changing the pollen catchment area reflected in the assemblage. It therefore gives information of a more regional nature, most relevant to the region south of the site. The values of *Fagus* in the assemblage are likely to be underestimating the importance of this tree in the area as *Fagus* is a relatively low pollen producer and is poorly represented in pollen spectra (Andersen, 1970; Bradshaw, 1981). It is probable therefore that *Fagus* was at least the second most important tree in the area at that time. Considering the changes in the pollen catchment area, it is possible that the *Fagus* pollen is largely derived from trees growing on the more calcareous soils of the chalk and related strata to the South (it would be a mistake, however to assume *Fagus* was restricted to calcareous soils). The amounts of *Betula* pollen seen in this zone are little changed from those seen in Zone BMP1A; this is more difficult to interpret. Possible sources of *Betula* pollen are again a regional component arriving mainly through stream input, reflecting gaps in the oak/beech canopy,and it is also possible that *Betula* was present on the heathland but this would be unlikely if the heath was being actively managed. The record of *Juglans* pollen is of note as this tree is often associated with gardens (Rackham, 1980) and could possibly represent local habitation.

A drop in *Corylus* pollen is observed, suggesting two possible changes in the local vegetation. If the *Corylus* pollen in BMP1A represented *Corylus* scrub near the sampling site, it is possible that this too has been flooded and killed by the rise in water table. Secondly it is possible that there was a degree of clearance of this species that coincided with the building of the Mill Pond, possibly to provide materials or fuel used during its construction.

Like *Betula*, the values of Gramineae pollen are similar to those observed in the previous zone. As previously mentioned, a new local source of pollen of this type could be from *Phragmites*, but it is also possible that *Phalaris*, and other swamp/fen grasses were present. When the ratio between the different size classes of Gramineae are studied, it can be seen that more grains with diameters in excess of 50µm are present. Two possible sources of these grains are from *Glyceria* (another possible member of the reed swamp community), or from cereals. Cereals are generally badly dispersed in air so the most likely source of them is via stream input (Vuorela, 1973). Their presence in the spectrum would therefore indicate local arable farming. The increases in the other herbaceous pollen types, especially *Plantago lanceolata* and *Rumex acetosa*, all presumably arriving largely via stream input, suggest that pastoral agriculture is taking place upstream of the pond. Pollen types such as Crucifereae and *Anthemis* could be indicators of either pastoral or arable land use (Behre, 1981).

Zone BMP1C.

If zone B can be seen as representing the period of change caused by the construction of the Mill pond, then the beginning of zone BMP1C can be seen as the point in time when the local system reaches equilibrium again after the change in hydrology. Evidence from the sample, from the top of this zone, dated by ^{14}C analysis at 320 ± 65 years B.P., suggests that this relatively stable period lasted until the first half of the seventeenth century, around 300 years after the pond was first built.

The high numbers of Cyperaceae, significant amounts of *Sparganium* and the presence of *Typha latifolia* suggests that the reed swamp community around the pond margins has become more fully established.

Alnus is present in much the same amounts as at the close of Zone BMP1B, presumably reflecting its continued presence around the lake margins. *Salix* increases in the upper two thirds of this zone, suggesting that this taxon has become more important in the waterside community.

Although the values of *Calluna* fall in this zone, it is likely that the levels present still reflect the local presence of heath. As previously mentioned, Bonny (1976) showed *Calluna* is poorly represented in lakes, even when surrounded by vegetation rich in this species.

The numbers of arboreal taxa can be seen from the summary diagram to be at their highest during this zone. *Quercus* is present at similar values to those seen at the end of the previous zone, suggesting that the regional importance of this taxon has changed little. *Fagus* however is seen to increase in importance. *Fraxinus* also increases in importance, and this is also a species poorly represented in diagrams (Andersen, 1970; Bradshaw, 1981). The drop in the amounts of *Betula* pollen seen in this zone may be related to the increase in these other species, as *Betula* could have been replaced in the course of woodland successional processes in the area.

The composition of the herbaceous spectrum is similar to that of the previous zone again suggesting the continued presence of both pastoral and arable farming in the catchment. The presence of *Polygonum aviculare* and *Papaver* in the spectrum provides even stronger indication of arable land use (Behre, 1981) than is seen in the previous zone.

Zone BMP1D.

Apart from changes in the pollen assemblage, the evidence from ^{14}C analysis suggests the rate of sediment accumulation has slowed down markedly in this zone. It appears that in around the first 300 years of the pond's existence around 120cm of sediment accumulated, while in this zone, which the sample ^{14}C dated at the top of the diagram would suggest lasted around 200 years, only 45cm of sediment has accumulated. This suggests the rate of sedimentation has roughly halved. This is almost certainly due to changes in the lake's hydrology, although there is little evidence in this diagram of any such event. Evidence from another core taken nearby (core BMP2 - to be discussed later) shows that the pond level was raised at around this time, possibly to its present level.

Also of note is that there is a change in the constitution of the sediment type in the upper part of the zone, moving from lake muds to reed swamp peats. This suggests that hydroseral progression at the margins of the pond moved the edge of the pond to roughly the point it occupies today. It is probable that this transition to reed-swamp peats also marks an increase in the rate of sediment accumulation, as the 2 metres of unconsolidated swamp peats present above the sediments making up this core, must have accumulated in around the last 120 years.

The build-up of the peat also has implications for the pollen recruitment into these sediments. The accumulation of material implies there is less lateral movement of pollen away from the sediments into the main body of the pond. However, it is probable that pollen would still be recruited from the main body of the lake. It would therefore be expected that locally produced pollen grains would be common in such peats. The relatively high peaks of *Filipendula* and Umbelliferae, as well as the high levels of *Alnus* present are almost certainly a reflection of this.

The slight drop in *Quercus* and *Fagus* seen in this zone is again most probably due to changes in pollen recruitment, rather than an actual decrease in the amount of woodland in the catchment area. The drop in the number of >50µm Gramineae pollen may also be due to the regional pollen spectrum becoming less well represented.

4.3 Burton Mill Pond Core 2 (BMP2)- Lake Core 2.

This core was originally taken to supplement the information gained from the previous core by providing data from the upper two metres of sediments which could not be retrieved from the first due to their fluid nature. It must be noted that this core was taken about 50 metres from the first, at the margin of the small inlet on the western side of the Mill Pond near the area of alder carr (see Fig. 3.2).

4.3.1 Stratigraphy.

0- 68cm Reed swamp peat.
68- 87cm Peat and lake mud transition.
87-111cm Lake mud.
111-126cm Lake mud, less organic.
126-142cm Lake mud with sand inwash.
142-156cm Lake mud.
156-200cm Monocot peat containing fine rootlets.

4.3.2 Pollen Stratigraphy.

This core was sub-sampled every 4cm along its length. As with the previous core a mininum of 500 pollen grains were counted in each sample, including a minimum of 100 arboreal pollen grains other than *Alnus glutinosa*. The summary diagram for this core is given by Fig. 4.9, the results being expressed as percentages of the total sum of pollen and spores (T.P.). However, the main pollen diagram for this core, Fig. 4.10 was constructed using

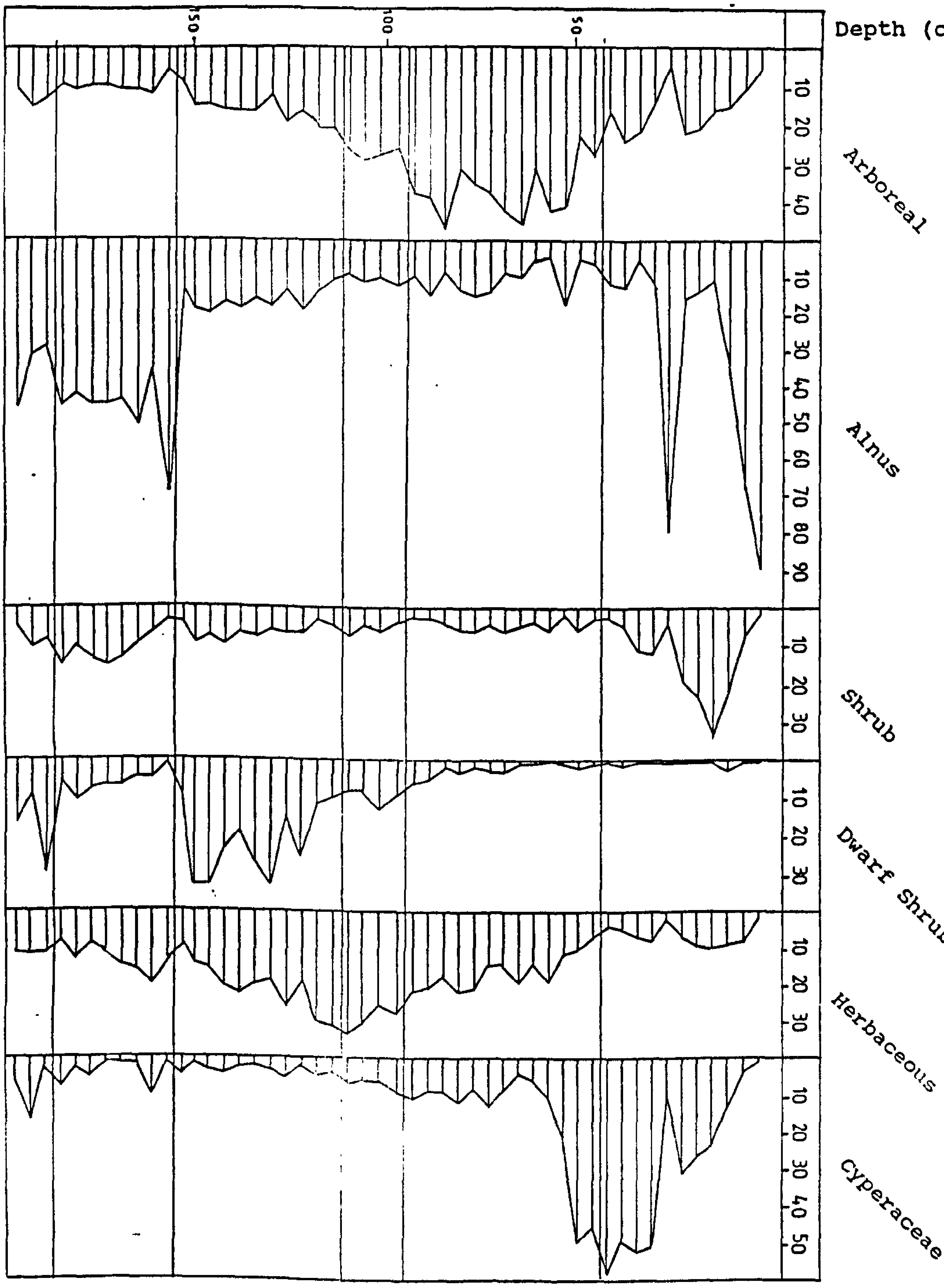


Fig. 4.9 BMP2 - Summary Pollen Diagram

(Values expressed as percentages of sum of total pollen and spores.)

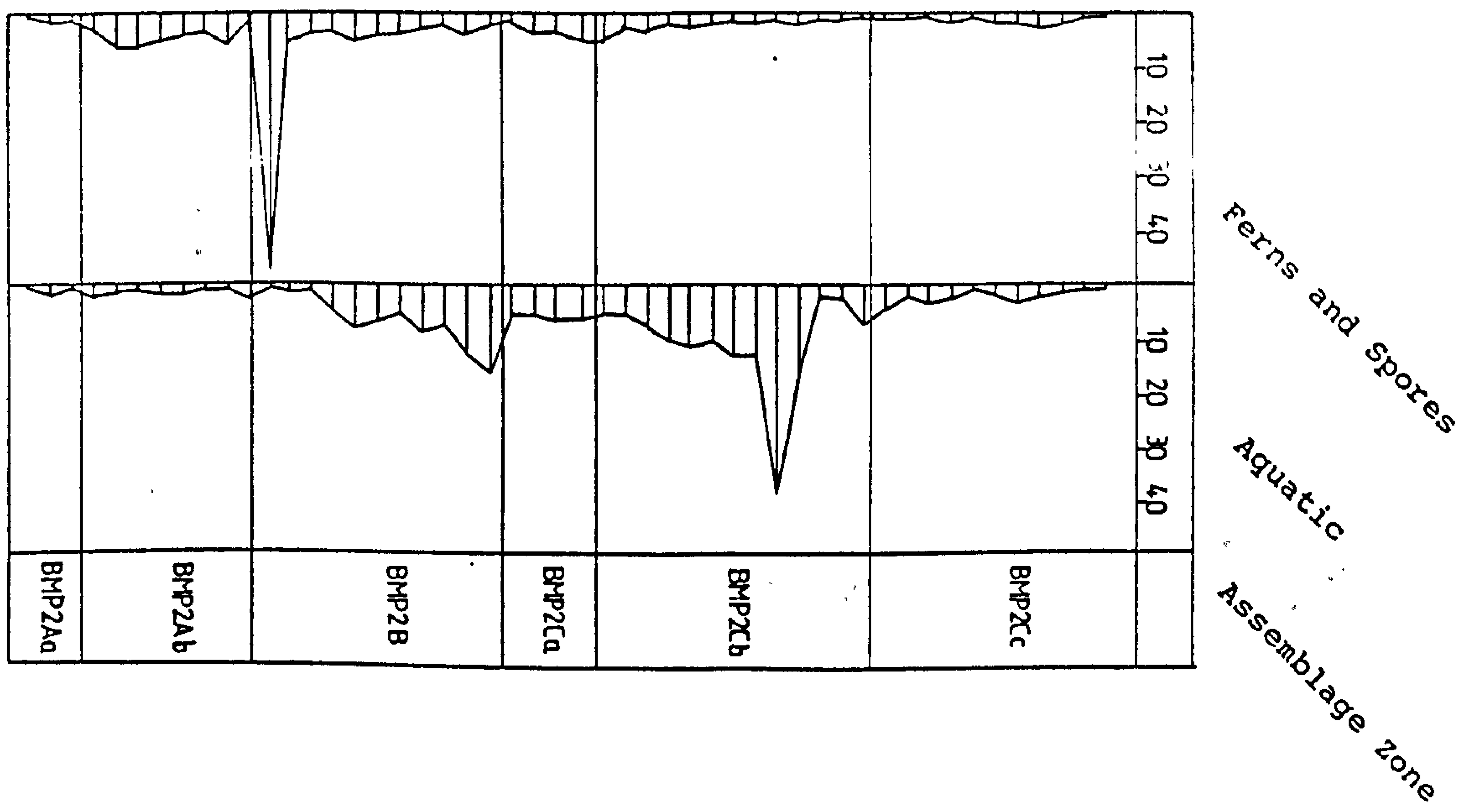

10 20 30 40
10 20 30 40
Ferns and Spores
Aquatic
Assemblage Zone
BMP2Aa
BMP2Ab
BMP2B
BMP2Ca
BMP2Cb
BMP2Cc

Fig. 4.9 (cont.)

Fig. 4.10 BMP2 - Main Pollen Diagram.
All values, except Alnus, Salix, Cyperaceae, Sphagnum and Sparganium type, are expressed as percentages of the ammended pollen sum. The values of Alnus, Salix, Cyperaceae, Sphagnum and Sparganium type are expressed as percentages of the total sum of pollen and spores. (+ represents values <1%)

Fig. 4.10 Cont.


Salix
Calluna vulgaris
Erica
Vaccinium
Ranunculus acris type
Cruciferae
Caryophyllaceae
Chenopodiaceae
Trifolium type
Lotus type
Vicia sylvatica type
Chrysosplenium
Filipendula
Rubus
Potentilla type
Geum
Rosaceae undiff.
Umbelliferae
Mercurialis
Polygonum aviculare
Polygonum convolvulus type
Rumex acetosella
Rumex acetosa
Rumex obtusifolius
Urtica type
Cannabis type
Lysimachia vulgaris
Myosotis type
Solanum nigrum
Stachys type
Plantago media/major type
Plantago lanceolata
Galium type
Succisa
Bidens type
Anthemis type
Artemisia
Centaurea nigra type
Liguliflorae
Gramineae<30μm
Gramineae 30-50μm
Gramineae>50μm
10 20 30
10 20 30 40

Fig. 4.10 Cont.

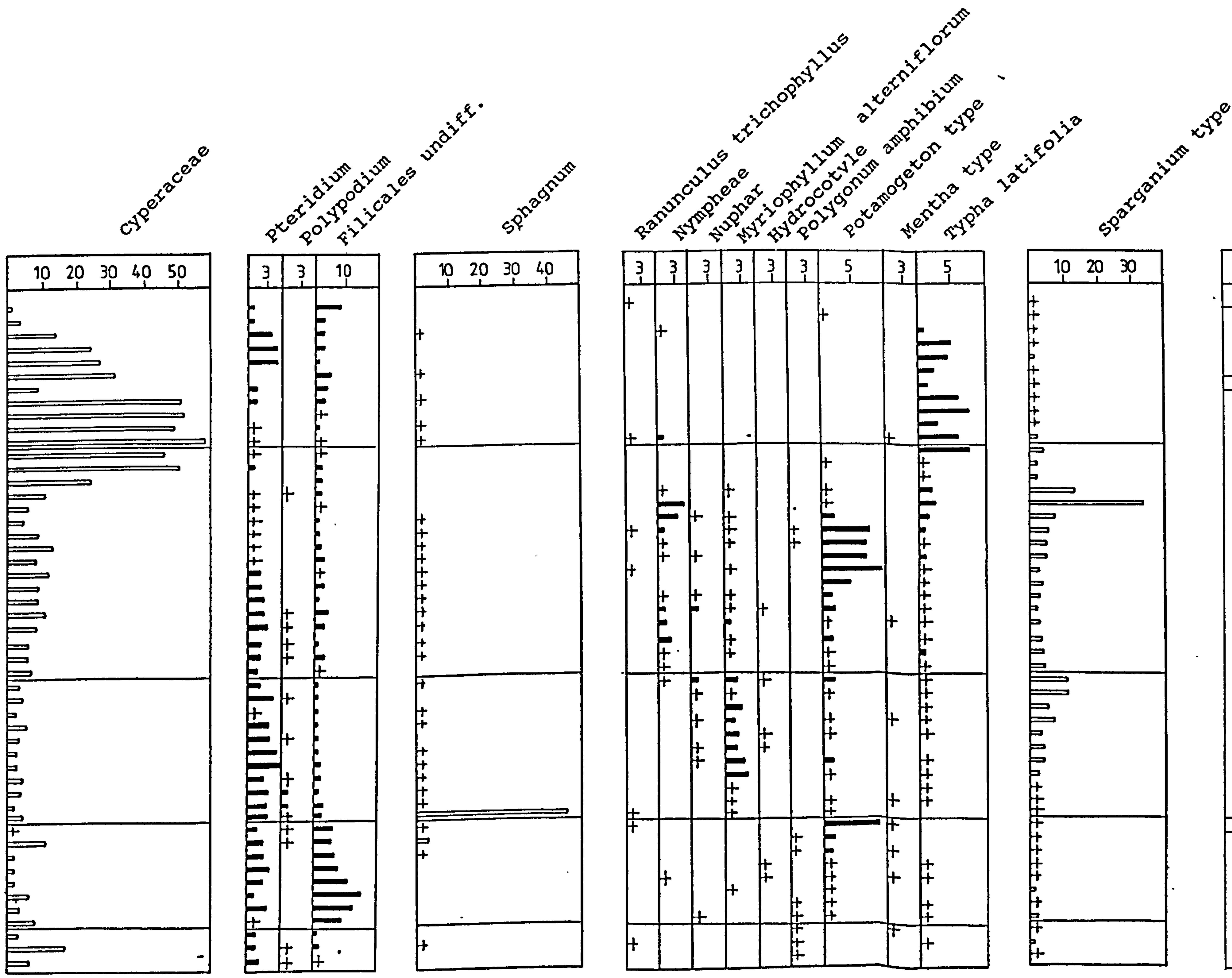


Fig. 4.12 BMP2 Results of Run 1 of the Zonation program.

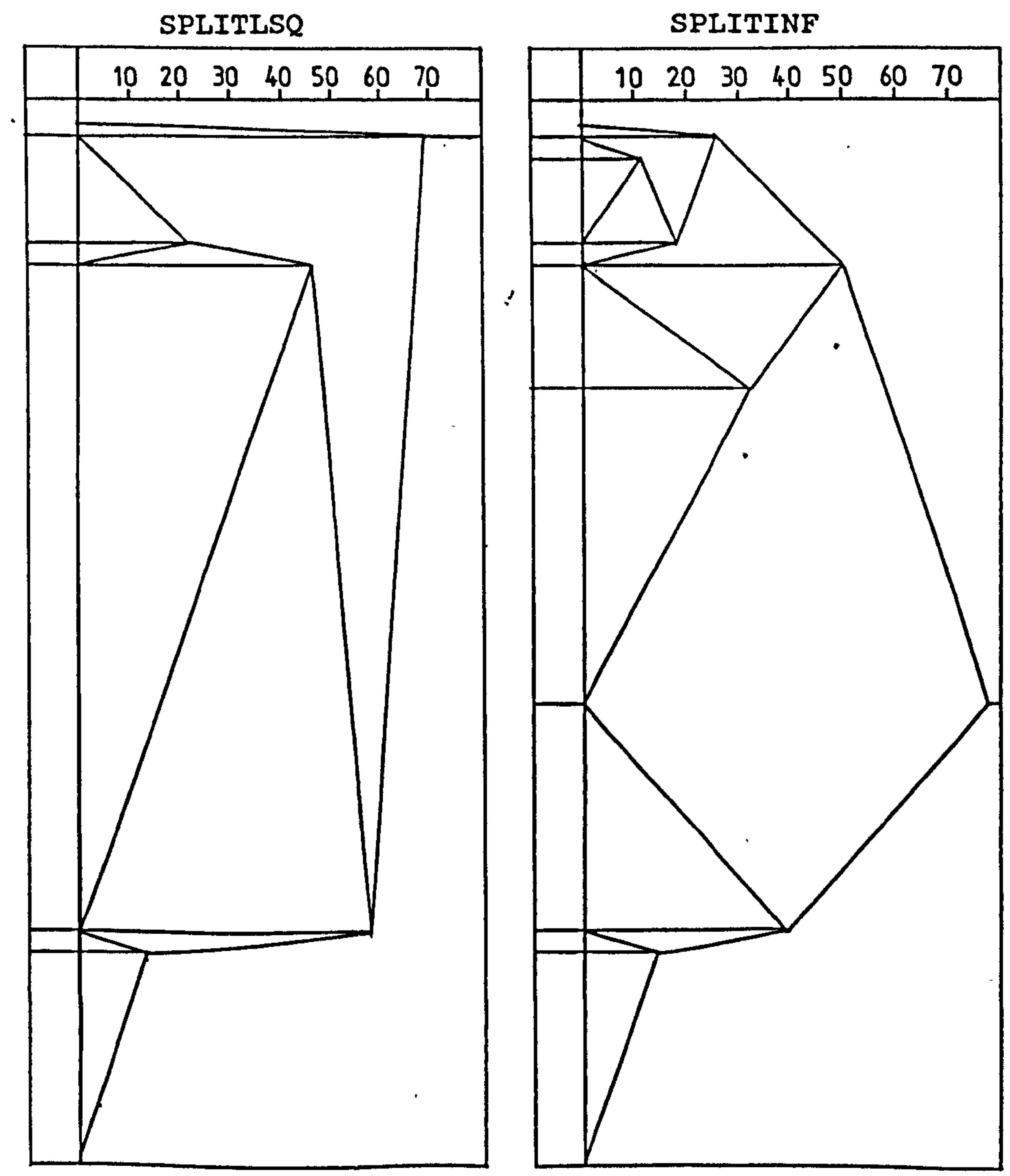


Fig. 4.12 Cont.

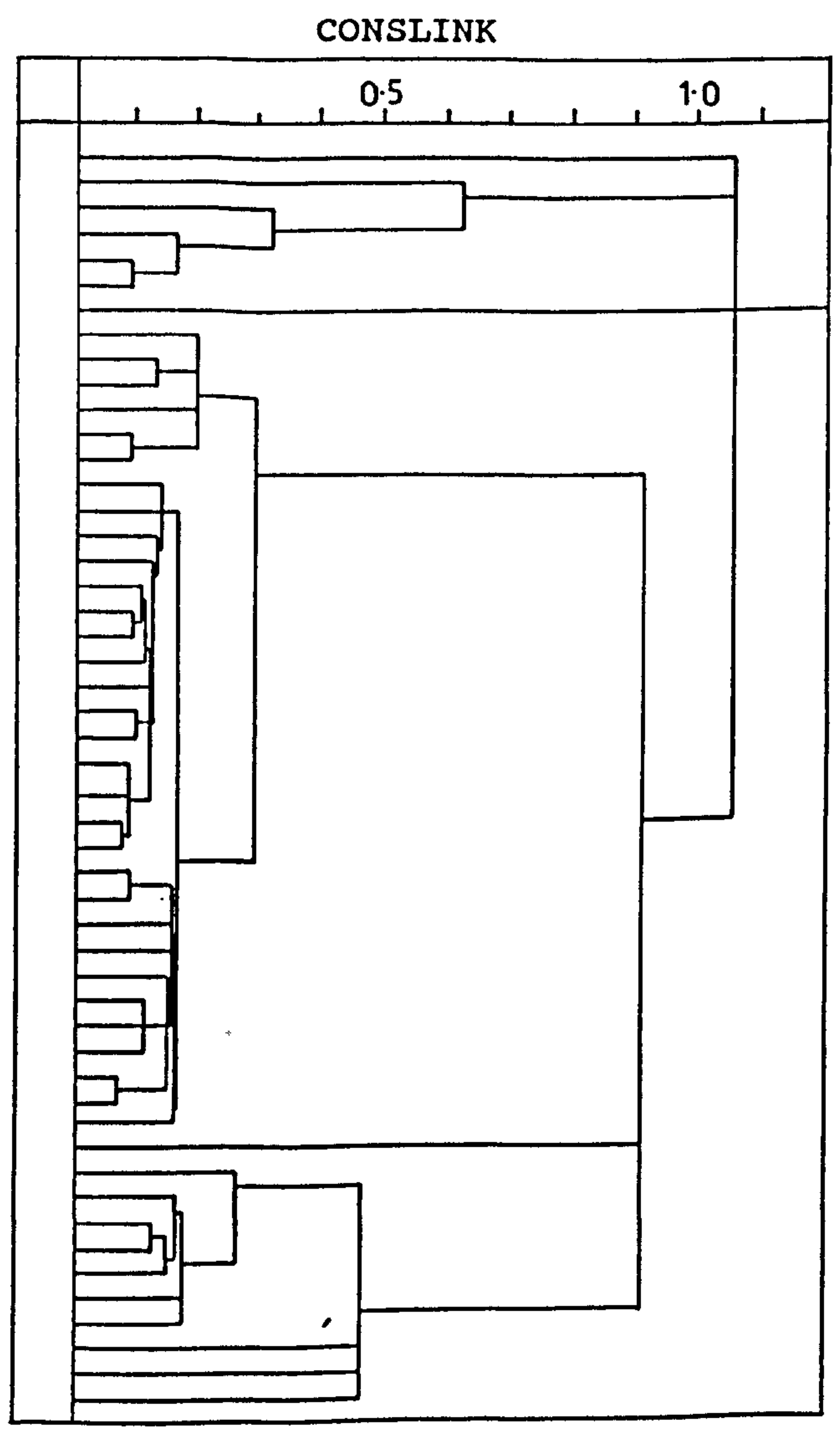
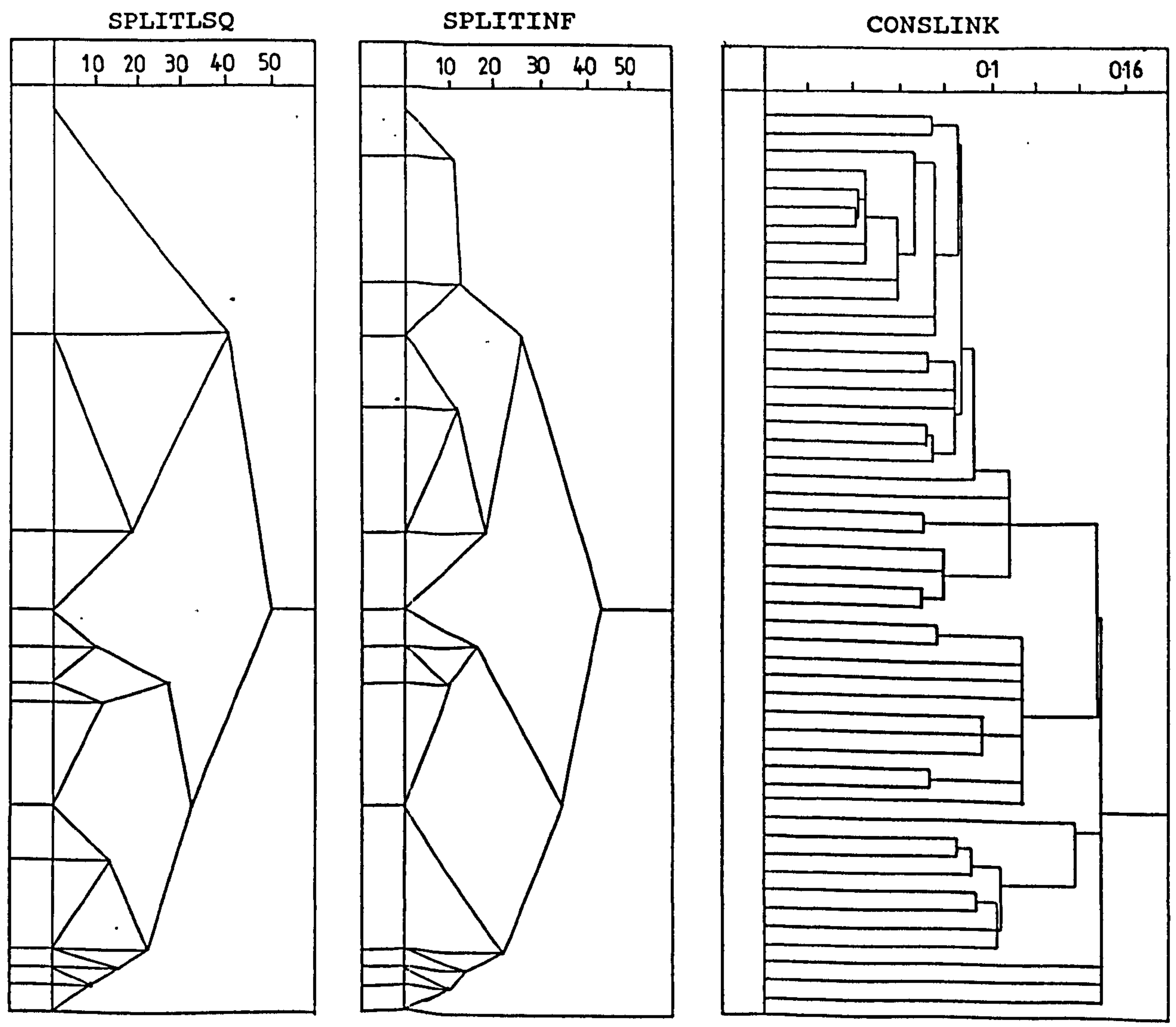


Fig. 4.14 BMP2 Results of Run 2 of the Zonation program.



the results expressed as percentages of an amended pollen sum (S.P.) where *Alnus*, *Salix*, Cyperaceae, *Sphagnum* and *Sparganium* are excluded from the pollen sum, as at some points these taxa show very high values and are presumably largely of local origin. The above pollen types are expressed as percentages of total pollen (T.P.).

The pollen types found in the analysis of this core that are not included in the main pollen diagram are given in Table 4.2.

4.3.3 Numerical Analysis.

Due to the high values of *Alnus*, *Salix* and Cyperaceae, DECORANA and the mathematical analysis programs were run twice, once including the above taxa and once excluding them. The species used in the two runs were:

Run 1: *Alnus*, *Betula*, *Pinus*, *Salix*, Cyperaceae, Gramineae, *Calluna*, *Quercus*, *Ilex*, Filicales, *Pteridium*, *Plantago lanceolata*, *Corylus*, Liguliflorae and *Fagus*.

Run 2: *Abies*, *Pinus*, *Betula*, *Quercus*, *Fagus*, *Fraxinus*, *Ilex*, *Corylus*, *Calluna*, *Ranunculus acris* type, Cruciferae, *Filipendula*, *Potentilla*, Liguliflorae, *Plantago lanceolata*, Gramineae, Filicales and *Pteridium*.

The results of these analyses are shown in Figs. 4.11 to 4.14.

DEPTH (cm)	POLLEN TYPE
0-1	*Picea, Athyrium filix-femina* (x2)
20-21	*Polygala*
32-33	Boraginaceae undiff.
36-37	*Myriophyllum spicatum*
56-57	*Caltha* type, Scrophulariaceae type,
64-65	*Rhinanthus*
72-73	*Myriophyllum spicatum*
76-77	*Circaea*
80-81	*Genista* type, *Populus, Papaver*
84-85	*Juglans*
92-93	*Rhamnus catharticus*
96-97	*Platanus, Geranium type, Myriophyllum spicatum, Menyanthes*
101-102	*Genista* type, *Osmunda*
113-114	*Linum catharticum, Fagopyrum* (x2) type
117-118	Leguminosae undiff., Boraginaceae undiff., *Solanum dulcamara, Veronica, Equisetum*
121-122	*Sanguisorba minor* (x2), *Athyrium filix-femina*
125-126	*Valeriana dioica*

Table 4.2 Pollen types found in BMP2 not included in the main pollen diagram

133-134	*Rosa, Veronica*
137-138	*Melampyrum, Rhinanthus* type
152-153	Leguminosae undiff.
156-157	*Centaurea cyanus*
160-161	*Caltha* type, *Solanum dulcamara*
164-165	*Lythrum portula*
168-169	*Valeriana dioica*
176-177	*Sorbus/Cratagus* type
180-181	*Valeriana dioica, Aster*
184-185	*Athyrium filix-femina*
196-197	*Carduus*

Table 4.2 cont.

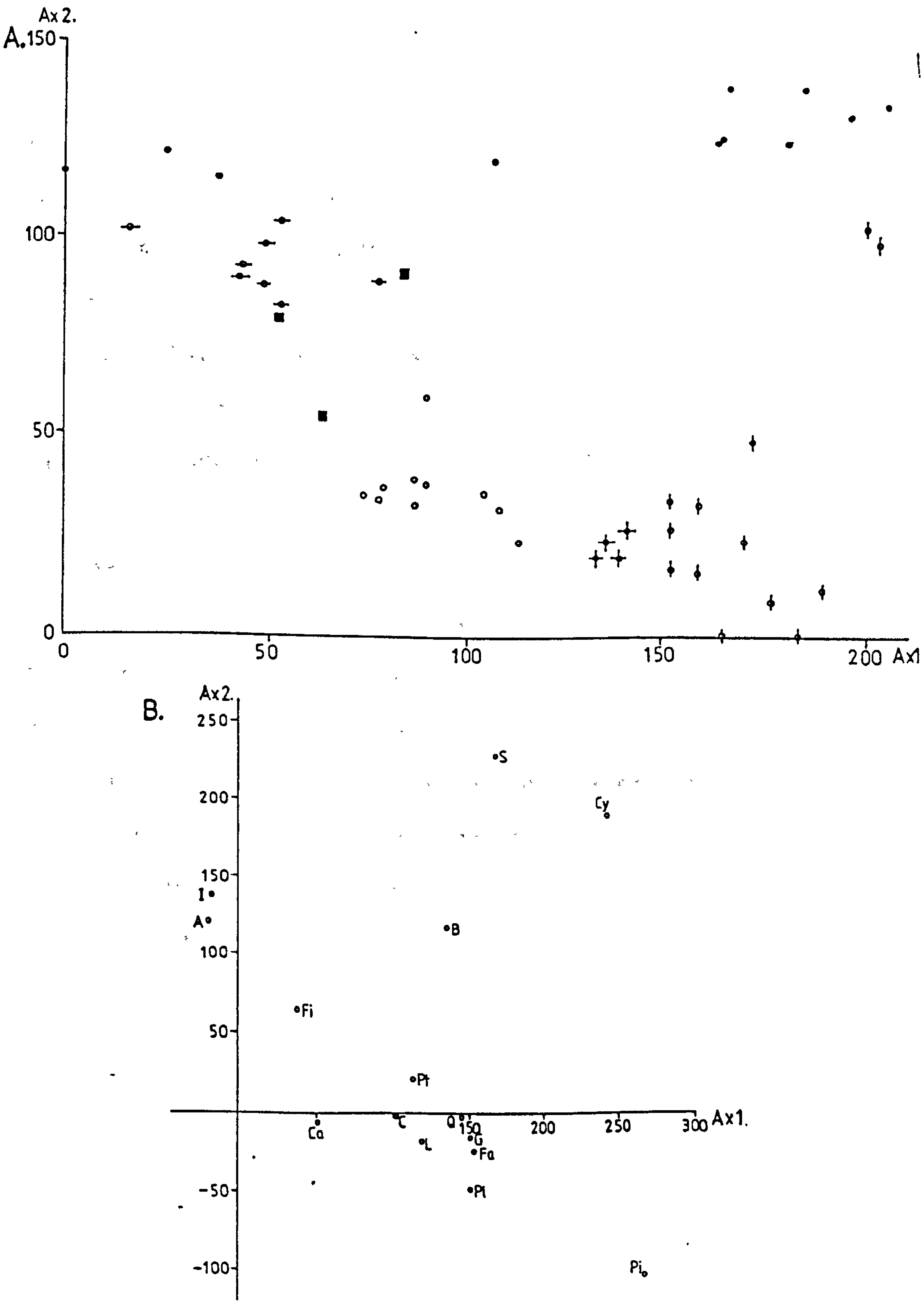


Fig. 4.11 BMP2-DECORANA Run1 A-samples B-Species.

(Key overleaf)

Fig. 4.11 (cont.)

Key

A: Samples.

■ Assemblage zone BMP2Aa

-o- Assemblage zone BMP2Ab

o Assemblage zone BMP2B

-+- Assemblage zone BMP2Ca

ϕ Assemblage zone BMP2Cb

● Assemblage zone BMP2Cc

B: Species.

A - Alnus	I - Ilex
B - Betula	Fi- Filicales
Pi- Pinus	Pt- Pteridium
S - Salix	Pl- Plantago lanceolata
Cy- Cyperaceae	C - Corylus
G - Gramineae	L - Liguliflorae
Ca- Calluna	F - Fagus
Q - Quercus	

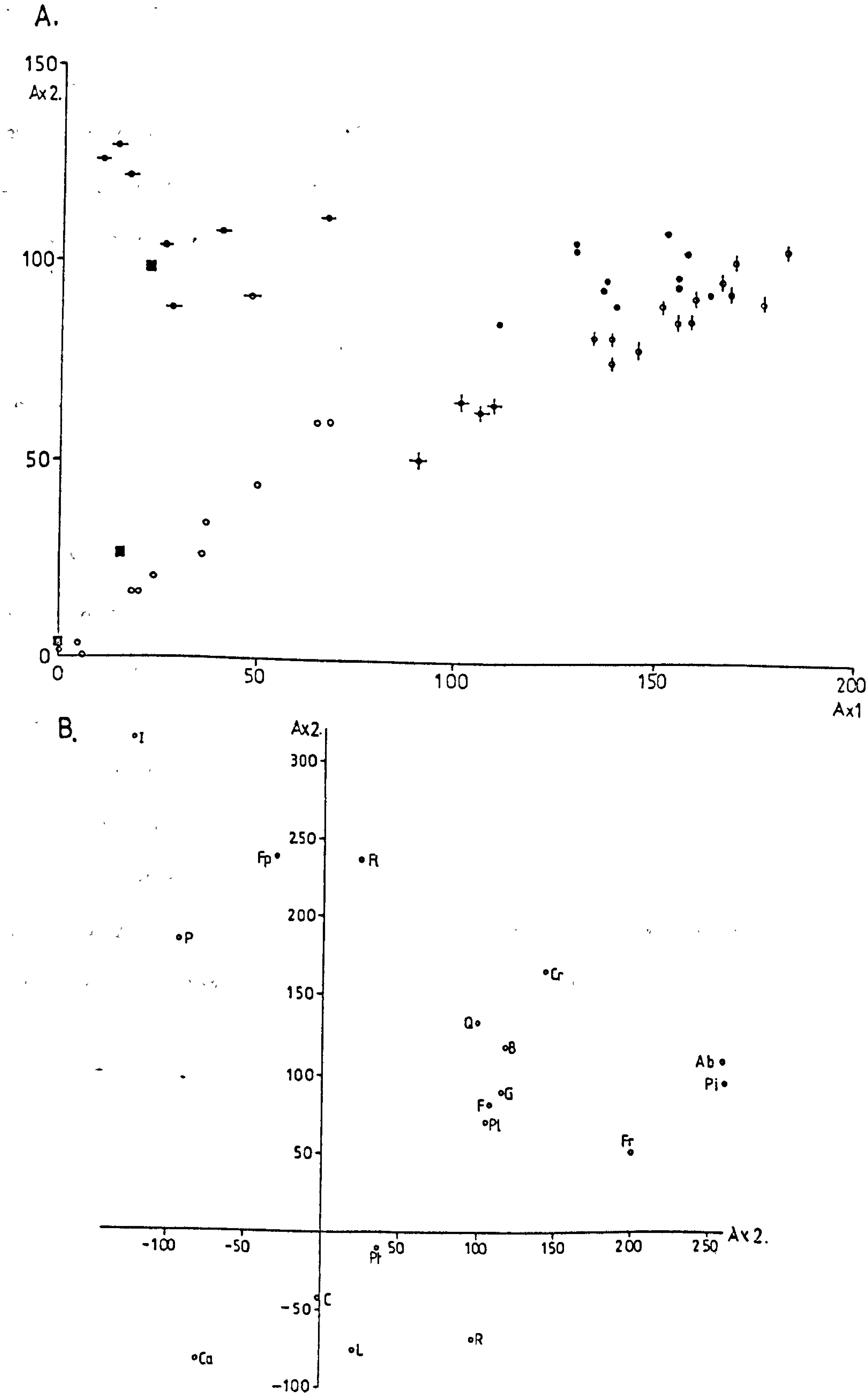


Fig. 4.13 BMP2-DECORANA Run2 A-samples B-Species.
(Key overleaf)

Fig. 4.13 (cont.)

Key

A: Samples.

■ Assemblage zone BMP2Aa

-o- Assemblage zone BMP2Ab

o Assemblage zone BMP2B

-+- Assemblage zone BMP2Ca

ϕ Assemblage zone BMP2Cb

● Assemblage zone BMP2Cc

B: Species.

Ab- Abies	I - Ilex
B - Betula	Fi- Filicales
Pi- Pinus	Pt- Pteridium
S - Salix	Pl- Plantago lanceolata
Fr- Fraxinus	C - Corylus
G - Gramineae	L - Liguliflorae
Ca- Calluna	F - Fagus
Q - Quercus	R - Ranunculus acris type
Cr- Cruciferae	Fp- Filipendula

4.3.4 Local Pollen Assemblage Zone Descriptions.

Zone BMP2A. Depth 200-156cm

It was decided to treat zone BMP2A as two sub-zones, since although there is a similarity throughout the samples making up this zone, samples 50, 49 and 48 do show a number of differences. In Run 1 of the mathematical programs, SPLITLSQ and SPLITINF do not find any significant split between these three samples and the rest of the group. However, CONSLINK shows them to be less closely linked than the other group members. In Run 2 of the programs, however, significant splits are found between samples 50 and 49, 49 and 48, and 48 and 47.

The upper boundary of zone BMP2A between samples 40 and 39 is seen to be significant in both Runs of the programs. In Run 1 there is also a significant split between sample numbers 41 and 40 in all of the programs, but this is almost certainly due to the influence of the high *Alnus* peak in this sample. The split indicated between samples 43 and 42 in Run 2 of SPLITLSQ is more difficult to explain however.

The DECORANA plots for both Runs 1 and 2 show the members of sub-zone BMP2Aa as outlying points of the main zone cluster. This is most dramatic in Run 2 where samples 50 and 48 are shown to be more closely related to the members of zone B than the rest of zone A. In both runs of DECORANA the members of sub-zone BMP2Ab form relatively well-defined groupings. The descriptions of these sub-zones are as follows:

Zone BMP2Aa. Depth 200-187cm

Alnus is numerically the most important pollen type in this sub-zone, however its values drop through the sub-zone from 47% T.P. in to 29% T.P.. Cyperaceae is also important in this sub-zone, but the levels present vary markedly between 4% and 17% T.P.. *Calluna* is the most important pollen type that is not excluded from the main pollen sum. Its percentages fluctuate between 18% and 46% S.P.. Gramineae is also common, and its values are stable through the sub-zone averaging 14% S.P.. *Quercus* is the most numerous arboreal pollen type, other than *Alnus*, in this sub-zone. Again the amounts present are seen to fluctuate, in this case between the values of 6% and 20% S.P.. *Fagus* and *Betula* are also well represented. The levels of *Betula* are relatively stable, averaging 10% S.P., while *Fagus* is present in smaller ammounts, reaching a peak of 4% S.P.. *Corylus*,the most numerous shrub pollen type present, varies between 4% and 9% S.P.. Account must be taken of the high numbers of *Ilex*, peaking at 15% S.P..

Zone BMP2Ab. Depth 187-156cm

Alnus is still the most important pollen in this sub-zone. However, apart from a peak of 70% T.P., it is present in much more stable amounts, averaging 45% T.P. in the rest of the sub-zone. Cyperaceae is again seen to fluctuate, varying between 1% and 11% T.P.. A change in the numbers of *Salix* occurs, rising to 6% T.P., and changing little in the rest of the sub-zone to average around 4.5% T.P..

The amounts of *Calluna* are lower than in the previous sub-zone. They reach a maximum of 21% S.P., but there is a tendency for the percentage to fall during this sub-zone, dropping to 4% S.P.. Gramineae, however is seen to increase slightly towards the top of the sub-zone. From a level of 15% S.P. it rises to 28% S.P..

The numbers of arboreal pollen types in the sub-zone are all relatively stable. *Quercus* averages 15% S.P. through the sub-zone, *Betula* drops slightly to an average value of 6% S.P., and *Fagus* is steady around 2% S.P..

Corylus is virtually unchanged throughout the zone.

Ilex is still present in large amounts, especially at the beginning of the sub-zone. It has a value of 20% S.P. but falls away towards the end of the sub-zone, dropping to 4% S.P.. The amounts of Filicales become important, showing a very similar pattern to those of *Ilex*, and peaking at 15% S.P., but falling to 6% by the end of the zone. *Pteridium* spores are relatively common through both sub-zones.

Filipendula reaches relatively high values in the upper half of the sub-zone, peaking at 7% S.P.. Both the abundance and the number of different herbaceous taxa are generally higher in this sub-zone than in the previous one.

Zone BMP2B. Depth 156-111cm

The upper limit of this zone, between samples 39 and

38 is mathematically well defined. In Run 1 it is shown to be the most significant by SPLITINF. However CONSLINK gives it only minor importance, while SPLITLSQ does not assign it any significance. Examination of the SPLITLSQ results from Run 1 shows that this program seems to be emphasising the importance of the changes in *Alnus* values. In Run 2 of the programs, this split is shown as the most important by both SPLITLSQ and SPLITINF, and of joint second importance by CONSLINK. It should be noted that both SPLITLSQ and SPLITINF show significant divisions within this zone; however, these are most likely to be simply due to relatively large fluctuations of *Calluna* in this zone.

Run 1 of DECORANA shows this zone as a distinct cluster, while in Run 2 the cluster has an elongate shape, almost certainly produced by the influence of differing amounts of *Calluna* pollen.

This pollen assemblage zone can be characterised by the drop in the values of *Alnus* pollen present and the increase in those of *Calluna* pollen. The amounts of *Alnus* are relatively stable, fluctuating between 10% and 20% T.P., and averaging 16% T.P. through the zone. The percentages of *Calluna* show much more variation, varying between 13% and 44% S.P.; however, a downward trend in the values of this pollen type can be detected. The amounts of Gramineae present have change little in this zone. There is a slight drop between samples 40 and 39, but by the end of the zone the numbers have increased again, averaging 19% S.P.. The summary diagram shows that the amounts of herbaceous pollen increase through this zone.

Little change in the numbers of arboreal pollen types is seen between this and the previous zone; the amounts of *Quercus*, *Betula* and *Fagus* are all still relatively stable, and their average values are virtually the same as in sub-zone BMP2Ab. The numbers of *Corylus*, although stable, are higher than seen in the previous zone, averaging 8% S.P..

Ilex and Filicales are much less important in this zone. *Ilex* shows this most markedly, never achieving a total above 1% S.P.. *Pteridum* replaces Filicales type as the commonest fern spore and *Filipendula* declines in importance.

Salix also drops, only achieving a maximum of 1.5% T.P. in this zone. The numbers of Cyperaceae present are much more stable than in the previous zone, and are lower, averaging less than 4% T.P.. An increase in the amounts of aquatic pollen types is seen, the most notable being *Myriophyllum alterniflorum* and *Sparganium*. The high percentage of *Sphagnum* in the bottom sample of zone, should also be noted, it accounts for 48% T.P. of this sample.

Zone BMP2C. Depth 111-0cm

Although there is a basic similarity throughout this zone, in that arboreal pollen types have increased in importance, changes particularly within the arboreal species warrant its division into three subzones. The results of Run 1 of the zonation programs is of little value in the interpretation of the data from these samples, as the changes in *Alnus*, Cyperaceae and, to a lesser extent, *Salix* can be seen as the major influence on this Run. The results from Run 2 of these programs, however, are more meaningful. The upper boundary of sub-zone BMP2Ca, between samples 25 and 24, is shown to be mathematically significant by all the zonation programs. However, the boundary of sub-zones BMP2Cb and BMP2Cc, between samples 12 and 11 is less distinct. There are several significant splits within these sub-zones, but the boundary between 12 and 11 is not one of them. The splits highlighted by the programs can be interpreted as merely reflecting fluctuations in the numbers of *Pinus* and *Betula*. The sub-zone boundary was placed between samples 11 and 12 because it is in sample 11 that the increase in *Betula*, the most important feature of sub-zone BMP2Cc, can first be detected.

Run 1 of DECORANA shows that the samples of BMP2Ca form a close cluster related to the bulk of the BMP2Cb samples but with slightly lower axis 1 scores. The samples of BMP2Cb form a distinct, but more diffuse cluster. Samples 13 and 12 form outlying points with high axis 2 scores, which is simply interpreted as being due to the high values of Cyperaceae in these samples. Sub-zone BMP2Cc is represented by a long thin cluster, the samples of which have consistently high axis 2 scores but a wide variation in axis 1 values. This is explained as reflecting the differing amounts of *Alnus*, *Salix* and

Cyperaceae in these samples.

Run 2 of DECORANA shows sub-zone BMP2Ca as a distinct grouping mid way between the samples of zone BMP2B and the rest of BMP2C. Sub-zones BMP2Cb and BMP2Cc are seen to be closely related, with an overlap between their sample clusters. However the two sub-zones can be seen to differ slightly in that the BMP2Cc samples are associated with a combination of slightly lower axis 1 scores and slightly higher axis 2 scores.

Sub-zone BMP2Ca. Depth 111-94cm

The most important feature of this entire zone, is the dramatic rise in the numbers of *Pinus* pollen. From only sporadic appearances in the previous zones, *Pinus* now accounts for an average value of 17% S.P.. The amounts of *Quercus* are lower but stable in this sub-zone, they average 9% S.P.. The numbers of *Betula* and *Fagus* however show little change from the previous zone, and change little within this sub-zone. The minor components of the arboreal pollen spectrum, for example *Castanea* and *Abies*, are more important in this sub-zone than in the previous zones.

The values of *Corylus* are stable but relatively low, averaging less than 5% S.P..

The percentages of *Calluna* present are similar to those in the upper samples of zone BMP2B, with values between 10% and 16% S.P.. *Gramineae* is at its most numerous in this sub-zone, and varies between 22% and 30% S.P.. The number of herbaceous pollen types recorded, however, are lower in this zone as a whole than in the previous zone.

Outside the amended pollen sum, *Alnus* is slightly less important, reaching a maximum of 13% T.P., and has an average value of 11% T.P. in the sub-zone as a whole. *Salix* is slightly more important, reaching 4% T.P.. The numbers of Cyperaceae are also slightly enhanced, with an average value of 7%.

Sub-zone BMP2Cb. Depth 94-43cm

This sub-zone is best characterised by an increase in the amounts of *Pinus* and a decrease in *Calluna*. The numbers of *Pinus* fluctuate quite markedly through this sub-zone between 28% and 48% S.P., while *Calluna* falls through this sub-zone to a minimum value of less than 1% S.P..

Quercus increases through this sub-zone, from around 10% S.P. at its beginning to 18% S.P. by the end of the sub-zone. The percentages of *Betula* and *Fagus* are similar to those seen previously, but a greater degree of variation is seen.

The amounts of *Corylus* again fall slightly, showing a peak of 8% S.P., but overall it averages less than 3% S.P. in this sub-zone.

The numbers of Gramineae are generally slightly lower than in the previous sub-zone, however they show more fluctuations, with a range of values between 12% and 25% S.P..

The values of *Alnus* pollen present vary quite markedly between 5% and 15% T.P.. *Salix* rises slightly but is still below 5% T.P.. A marked increase is seen in the numbers of Cyperaceae pollen during this zone, however. Between samples 24 and 15 it generally accounts for around 10% T.P., but it then rises rapidly to values in the region of 50% T.P..

Aquatic pollen types are again significant in this sub-zone. *Potamogeton* reaches values above 5% S.P. in some samples, while the numbers of *Typha latifolia* and, particularly *Sparganium* type which peaks at 35% T.P., increase in the upper samples of this sub-zone.

Sub-zone BMP2Cc. Depth 43-0cm

As mentioned previously, this sub-zone is characterised by the increase in the amount of *Betula*. The values of *Betula* pollen present vary between 12% and 30% S.P., but has an average value of 17% S.P. overall.

Numerically, however, this sub-zone is dominated by *Alnus*, *Salix* and Cyperaceae. *Alnus* is seen to increase through this zone from 12% T.P. to 90% T.P. This increase is not a steady one, however; large fluctuations such as a peak of 80% T.P. are seen. Cyperaceae behaves in the opposite manner, dropping from 59% T.P. to 1% T.P.. An increase in the importance of *Salix* is also seen, increasing from 2% T.P. up to a peak of 33% T.P.. However it then decreases rapidly to 1% T.P. by the top of the diagram.

Pinus is still the most numerous arboreal pollen type after *Alnus*, being present in slightly lower amounts than in the previous sub-zone. It shows a tendency to drop in importance through this zone, falling from 37% S.P. at the beginning of the zone, to values of less than 20% S.P. in the uppermost samples of the core. *Quercus* remains important, fluctuating between values of 16% and 5% S.P.. The numbers of *Fagus* fall away in this sub-zone.

Corylus and *Calluna* have changed little from the previous sub-zone, both averaging around 2.5% S.P.. Likewise Gramineae has changed little, averaging 18% S.P. in this sub-zone. *Pteridium* and Filicales both increase in the uppermost samples.

Aquatic pollen types are much less important in this sub-zone, with the exception of *Typha latifolia* which is relatively numerous.

4.3.5 ^{14}C Analysis.

Four samples from this core were selected for ^{14}C analysis. These were as follows:

1. SRR-3415 This sample was taken from the peats between the depth of 190-200 cm beneath the present surface. It gave a date of 730 ± 70 years B.P..
2. SRR-3414 Taken from the peats between the depth of 150-160cm beneath the present surface, this sample gave a date of 330 ± 65 years B.P..
3. SRR-3413 Made up of the lake muds from the depth of 105-115 cm beneath the present surface, this sample gave a 'modern' date (70 ± 75 years B.P.).
4. SRR-3412 This sample, taken from the reed-swamp peat

at the depth of 30-42cm below the present surface. It gave a 'modern' date.

The positions of these samples and the dates associated with them are also shown on the main pollen diagram (Fig. 4.10).

4.3.6 Local Pollen Assemblage Zone Interpretation.

Zone BMP2A.

The two sediment samples ^{14}C dated that are relevant to this assemblage zone provide evidence in establishing when it both started and ended. The lowest sample, SRR-3415, suggests that the sediments at the start of this zone could date from the early part of the thirteenth century. These lower sediments therefore almost certainly predate the building of the mill pond. The sample, SRR-3414, that encompasses the upper boundary of the zone suggests that it lasted for around 400 years.

Sub-zone BMP2Aa.

Although the zone has been split into two sub-zones, *Alnus* is important throughout, suggesting that the immediate vegetation to the sampling site was alder carr. This is also important when considering the pollen recruitment processes acting while these sediments accumulated. The fact that the zone is made up of peats formed in an alder car suggests that a large quantity of the pollen arriving into the sediments is of local origin. But there must also have also been a quantity of waterborne pollen arriving at the site if one considers the wet nature of this habitat. The *Frangula* and *Chrysosplenium* recorded in the assemblage can be assumed to reflect components of the local alder carr community. The relative importance of *Cyperaceae* also reflects wet conditions.

The *Calluna* present is presumed to reflect the presence of heathland elements near to the pond. Records of *Erica* and *Vaccinium* pollen add weight to this hypothesis.

As *Quercus*, *Betula* and *Fagus* are the only important arboreal species, it would seen that a similar regional spectrum of woodland as seen in the BMP1 core is found here, that is a mixture of oak and beech woodland. The birch was presumably present in gaps of the canopy of the other trees. Again the *Corylus* in the assemblage is probably regionally derived, either reflecting its presence in the woodland understory, or more likely its use in coppice with standard management of the woodland.

The diversity of herbaceous pollen types, similar to that seen in BMP1, and especially the relative importance of *Plantago lanceolata* and the presence of possible cereal grains, suggests that areas of both pastoral and arable farmland are also present locally.

The relative abundance of *Ilex* in the assemblage is important. This dioecious species is reported to be poorly represented in surface samples from under a canopy containing the shrub (Aaby, 1983). It would therefore seem unlikely that the amounts found here are a reflection of the presence of the species in the immediate area. It is possible however that this pollen type has arrived via the water transport of eroded woodland soils (Pennington, 1979; Moore, Evans and Chater, 1986).

Sub-zone BMP2Ab

The evidence from the ^{14}C dating of this core suggests that the mill pond was built during the period covered by BMP2A. It is possible that the change from BMP2Aa to BMP2Ab marks the point at which the pond was constructed. The evidence which suggests that this might be the case is the increase in amounts of *Alnus*, *Salix* and the higher number of aquatic pollen types represented in BMP2Ab. It is also possible that some of the other changes seen in this sub-zone are caused, at least in part, by changes in pollen recruitment processes brought about by the building of the mill pond. However, it is impossible to be positive about any of the above hypotheses. No changes in the sediments are seen at this point, only changes in the pollen assemblage. This tells us that even if this point does reflect changes in the local hydrology rising from the building of the mill pond, the mill pond itself may still be physically separate from the alder car represented in this zone.

One of the major factors in splitting this zone into two sub-zones is the increased importance of Filicales and the constantly high values of *Ilex* in these samples. As previously mentioned, the *Ilex* is likely to be derived from soil erosion. It is possible that the Filicales is also derived from woodland soils. Filicales is often an important component of the pollen and spore spectra from woodland, and as this spore type is resistant to decay it could easily accumulate in the soil. It would seem more probable, therefore, that the amounts of soil-derived material arriving in the sediments has increased in the upper sub-zone. This implies either a degree of forest clearance in the catchment area, leading to soil erosion (and that this process was intensified around the start of this sub-zone) or that soils in the catchment were destabilised by other factors such as the intensive use of fire in heath management, or due to coppice management systems.

The other differences between the sub-zones are probably due to much more local factors. The increase in *Salix* is most likely due to the establishment of this species close to the sampling site, possibly in response to opening up of the canopy by coppicing of the alder. The high numbers of *Filipendula* and, to a lesser extent, those of *Galium*, *Rubus* and *Potentilla*, are almost certainly again due to local occurrence of these plants. The increase in Gramineae seen in this sub-zone is most strongly apparent in grains between the size range of 30-50µm. It is likely that the increase is derived from locally growing grasses such as *Phragmites* and *Phalaris*. Again we see possible indicators of both pastoral and arable agriculture in the herbaceous component. Of note is the record of *Centaurea cyanus*, a pollen type strongly associated with cereal cultivation (Behre, 1981).

The slightly lower values of *Calluna* seen in this sub-zone are not thought to be particulary important in terms of vegetation change, they are probably due to the local variations in cover, and as a statistical result of the increases seen in other pollen types.

That little change is seen in the arboreal spectrum, and also in *Corylus*, could be a reflection of the stability of the regional vegetation. However, the possibility exists that a proportion of these pollen types have been derived from soil erosion, perhaps itself a consequence of deforestation.

Zone BMP2B.

The start of this assemblage zone is marked by a sharp change in stratigraphy from swamp peats to lacustrine sediments, showing that there has been a rise in the water level and that open water now covers the sampling site. As mentioned earlier, evidence from ^{14}C analysis suggests that this change took place around the early part of the seventeenth century. It is known that the mill pond was the site of a forge that was working in the mid part of this century (Straker, 1931). The fact that this was situated far from any furnace implies that the reason for its location was to take advantage of the good water supply provided by the high rainfall on the nearby South Downs. It therefore follows that the increase in water level was due to the dam being extended in association with the building of the forge. The results from the ^{14}C give a date for the end of this assemblage zone as 70 years before present (± 75 years), which suggests that it most probably lasted until some time in the last century.

The increase in the water level means that the pollen recruitment processes, such as those outlined in the interpretation of BMP1B will now apply. The replacement of carr by open water means that more pollen would have been carried to the site via water transport. The size of the pollen catchment area will be larger than that seen in the previous zone, and the vegetation immediately around the pond will be contributing a lower proportion of the pollen assemblage.

The drop in *Alnus* pollen is simply explained as being due to the loss of the tree from the immediate vicinity of the sampling site, and to the fact that the pollen is no longer largely being directly incorporated into the sediments, but is now being mixed with the pollen in the lake that entered via stream input. However, the amounts of *Alnus* pollen in the assemblage are still significant, suggesting that either some areas of alder carr persisted despite the rise in the water level, or new areas of carr quickly became established. It is probable that a similar distribution of alder carr to that seen at the site today became established in this zone. The drop in *Salix* pollen is again probably due to the same reasons as the drop in *Alnus*. The amounts of *Calluna* pollen found in this assemblage zone are, as in the BMP1B assemblage, higher than might be expected in lacustrine sediments. The fact that this pollen assemblage follows a rise in water level suggests that some of the pollen, especially in the lower parts, was derived via erosional events associated with the rise in water level which presumably involved flooding areas of heath. If deforestation was the cause of the erosion indicated in the previous zone, the areas cleared might now carry heath.

The similarity in the values of arboreal pollen between this and the previous zone, however, does suggest that the composition of the woodland in the catchment area of the mill pond was relatively constant.

Since this assemblage was deposited at a time when the active management of woodland was presumably being widely practised, the increase in *Corylus* will almost certainly indicate an increase in the area of coppice in the region (see Appendix 1).

Apart from the falls in *Filipendula* and *Galium* type, probably due to the loss of bankside vegetation that caused the drop in alder mentioned previously, the spectrum of herbaceous pollen types is generally similar to the previous zone and can be interpreted as again showing the presence of both pastoral and arable activity. Liguliflorae type is seen to increase in importance more strongly than other species. Unfortunately this cannot be clearly interpreted as it may be an indicator of a number of different communities (Behre, 1981). One arable indicator not previously recorded in the diagram is *Fagopyrum*, a species which is thought to have been introduced into the British Isles during the Roman period and which was often grown as a crop plant, especially on light sandy soils (Godwin, 1975). The records of *Linum catharticum* and *Sanguisorba minor* are notable as they may give an indication of the size of the pollen catchment area. Both are calcicole species and are therefore likely to originate from the chalk downs a few miles to the south.

The shape of the *Sparganium* curve and the fact that *Typha latifolia* is more frequent in the top half of the zone suggest that the reed swamp community around the margins of the pond did not become fully re-established immediately after the rise in water level. The amounts of Cyperaceae in this zone are markedly lower than in the BMP1C assemblage, which was also formed under open-water conditions and therefore might have been expected to be similar. This might be explained by the rise in water level drowning areas that formerly supported vegetation rich in Cyperaceae. As might be expected, open-water aquatic plants are represented in the assemblage.

Zone BMP2C.

The two ^{14}C dates associated with this zone both give modern dates. This tells us that all the events seen in this zone must have taken place in the last 100 years or so, and that the sedimentation rate appears to be faster than that seen in the previous zones.

Sub-zone BMP2Ca.

The sudden increase in *Pinus* shows the introduction of this species into the area. This initial introduction is almost certainly due to planting. The fall in the numbers of *Quercus* and *Corylus* may be due to a statistical artefact caused by the increase in *Pinus*. However, it cannot be ruled out that some areas of *Quercus* woodland and *Corylus* coppice have been grubbed out and replanted with pine.

It is possible some of the heath in the area was planted with pine. However, *Calluna* is still relatively important in the assemblage, especially if one takes into account that the assemblage occurs in lacustrine sediments. This would suggest that some open heath is still present.

The first appearance of significant amounts of *Castanea* pollen occurs in this zone. This too could reflect the establishment of this species in the area, perhaps in situations such as the *Castanea* coppice found in the New Piece today (see Fig 4.2).

The similarity of the herbaceous spectrum to those seen in the previous zone again indicates agricultural activity in the region.

It is unlikely that the slight drop in *Alnus* represents any real change in its importance in the areas of carr around the pond. *Salix*, however, would appear to have become more important in this community.

Sub-zone BMP2Cb.

The further increase in *Pinus* and the drop in *Calluna*, suggests that pine is now definitely becoming established on local heathland. It is doubtful that Pine was actively planted on the heath, it is much more likely that a change in the management of the heathland allowed the invasion of the pine. Probably a drop in grazing pressure was the cause, although the cessation of cutting the heath might also be a contributory factor in the survival of tree seedlings.

The gradual increase in *Quercus* could again be due to the establishment of this tree on the former areas of heathland. Rackham (1980) states that oak can act as a primary pioneer tree; however, due to its slower maturing and onset of flowering (*Quercus* takes at least 25 years to mature, while *Pinus* can flower in as little as 5 years (Wareing, 1959)), its presence would not be as quickly apparent as other trees in the pollen spectrum.

The stratigraphy of the core shows a transition from lake muds at its start through to reed-swamp peat near the top of the sub-zone. This change in lithostratigraphy is accompanied near the top of the sub-zone first by the rise in the numbers of *Sparganium* type and *Typha latifolia* pollen, and then by the rise in Cyperaceae. This suggests that as the margins of the lake silted up a hydroseral succession became evident, with an extension of the lake-side reed-swamp.

Changes in pollen recruitment processes are also implied by the change in sediment type. These have been more fully discussed in relation to BMP1.

BMP2Cc.

The increase in *Betula* and decrease in the amounts of *Pinus* suggest that there has been a partial clearance of pine allowing the establishment of birch, or that birch has become established in already existing gaps in the pine canopy, and the fall in pine is a statistical artefact rather than a real event.

The continuation of the lakeside hydroseral progression is seen to continue with the establishment of *Salix*, then *Alnus* near the sampling site. The accompanying fall in Cyperaceae near the top of the sub-zone presumably reflects an increase in shading due to these trees. The increase in *Typha latifolia* reflects the proximity of the reed bed to the sampling site.

As the local conditions became drier with the accretion of sediments (this core was taken from a terrestrial site a few metres inland from the Mill Pond's edge), the amount of pollen in this assemblage arriving via the lake waters will have become smaller. This accounts for the further drop in the numbers of herbaceous pollen. It also implies that the larger Gramineae grains recorded, are more likely to be derived from locally growing grasses rather than cereals.

4.4 Burton Mill Pond Core 3 (BMP3)- Valley Mire Core.

This core was taken fom the small area of valley mire in the Newpiece area of the Nature Reserve to the West of the Mill Pond (see Fig. 4.2).

4.4.1 Stratigraphy.

0- 62cm Unhumified Sphagnum peat.

62- 75cm Humified peat consisting mainly of well humified monocotyledonous roots.

75- 79cm Silt inwash.

79- 89cm Well humified monocot peat.

89- 92cm Silt inwash.

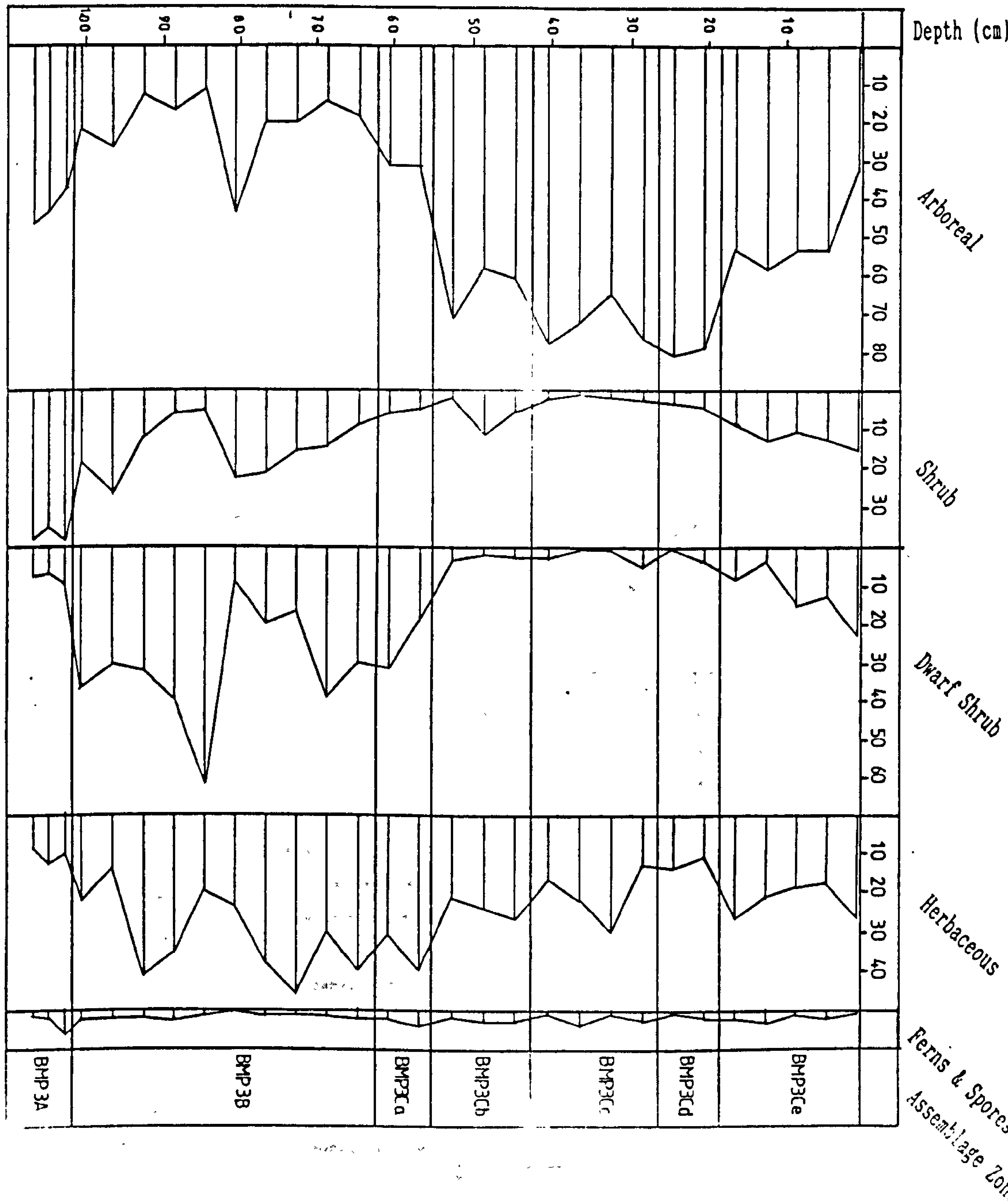
92-107cm Well humified monocot peat.

4.4.2 Pollen stratigraphy.

This core was sub-sampled every 4cm to a depth of 100cm, then sub-sampled every 2cm. At least 500 pollen and spores, excluding *Sphagnum*, were counted for each level. Both the summary diagram (Fig. 4.15), and the main pollen diagram (Fig. 4.16) are constructed using pollen values expressed as percentages of total pollen and spores, excluding *Sphagnum*, (T.P.). Those species found in this core but not included in the main pollen diagram are given in Table 4.3.

4.4.3 Numerical Analysis.

The pollen types used in the numerical analysis of the data were: *Pinus*, *Tilia*, *Ulmus*, *Betula*, *Alnus*, *Fagus*,



<u>Fig. 4.15 - BMP3 Summary Pollen Diagram.</u>

(Values expressed as percentage of sum of total pollen and spores.)

Fig. 4.16 BMP3 - Main Pollen Diagram
All values expressed as percentages of the ammended pollen sum.(+ represents values <1%)

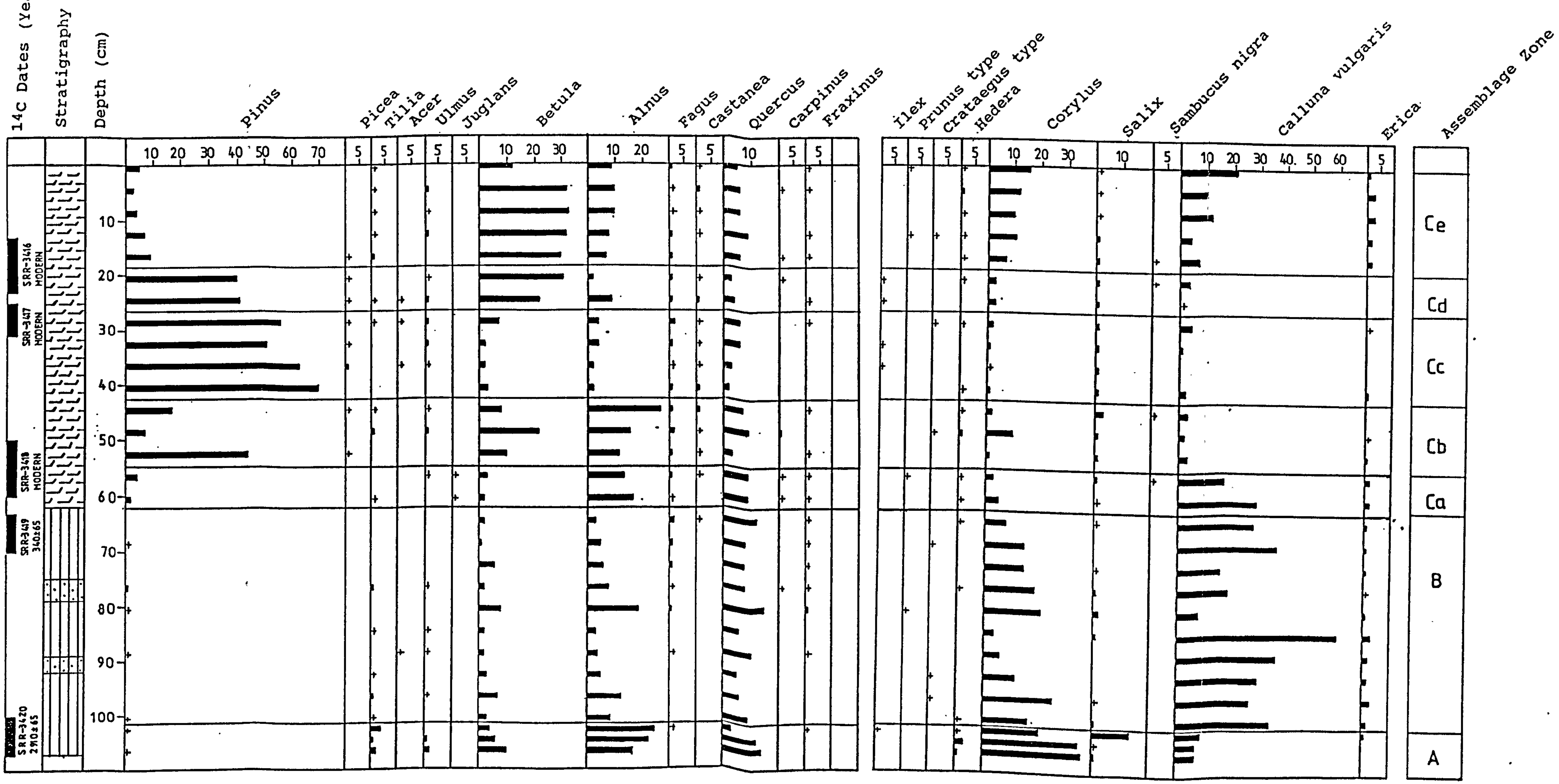


Fig. 4.16 Cont.

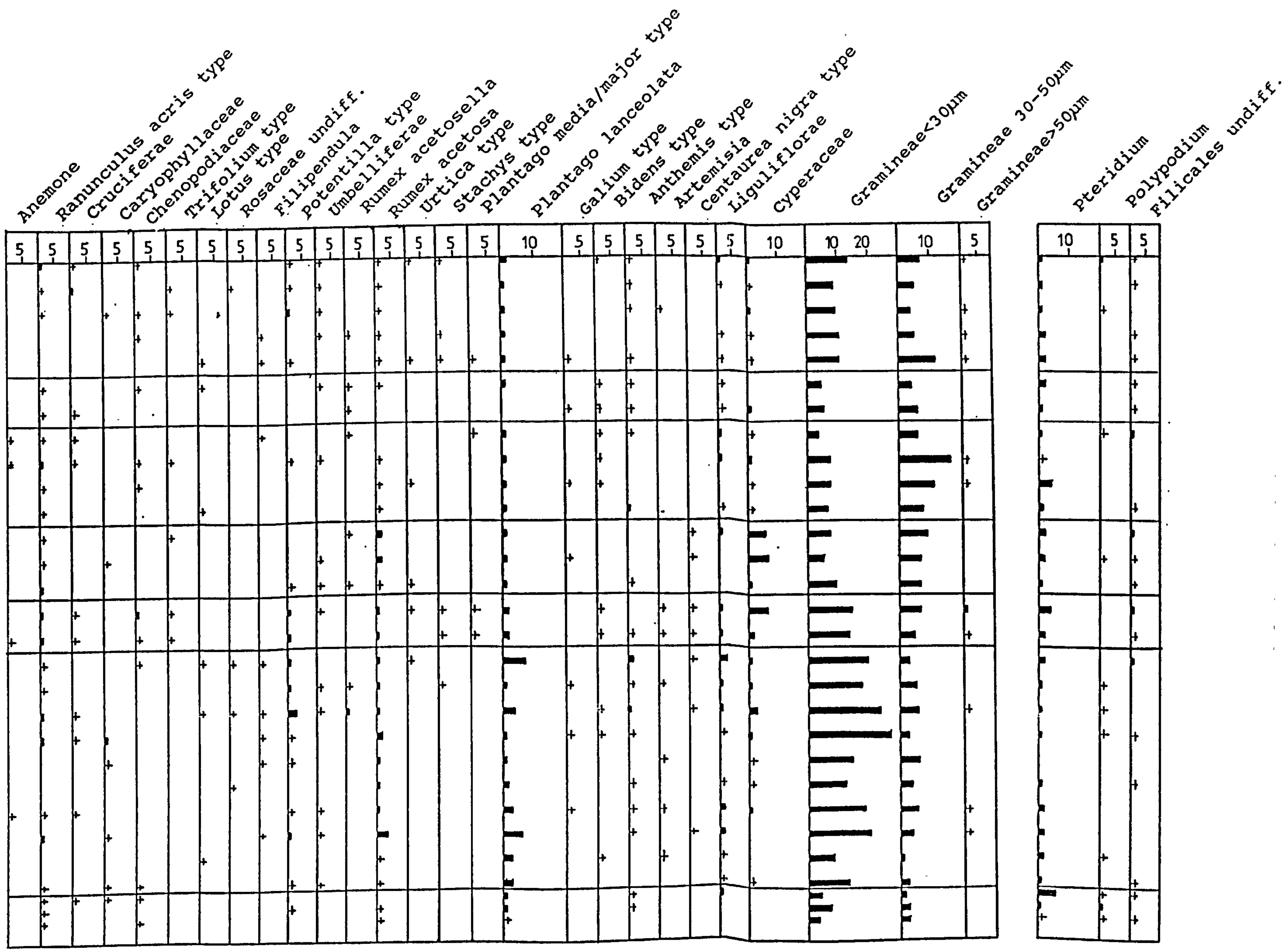

Anemone
Ranunculus acris type
Cruciferae
Caryophyllaceae
Chenopodiaceae
Trifolium type
Lotus type
Rosaceae undiff.
Filipendula
Potentilla type
Umbelliferae
Rumex acetosella
Rumex acetosa
Urtica type
Stachys type
Plantago media/major type
Plantago lanceolata
Galium type
Bidens type
Anthemis type
Artemisia
Centaurea nigra type
Liguliflorae
Cyperaceae
Gramineae<30μm
Gramineae 30-50μm
Gramineae>50μm
Pteridium
Polypodium
Filicales undiff.

Fig. 4.16 Cont.

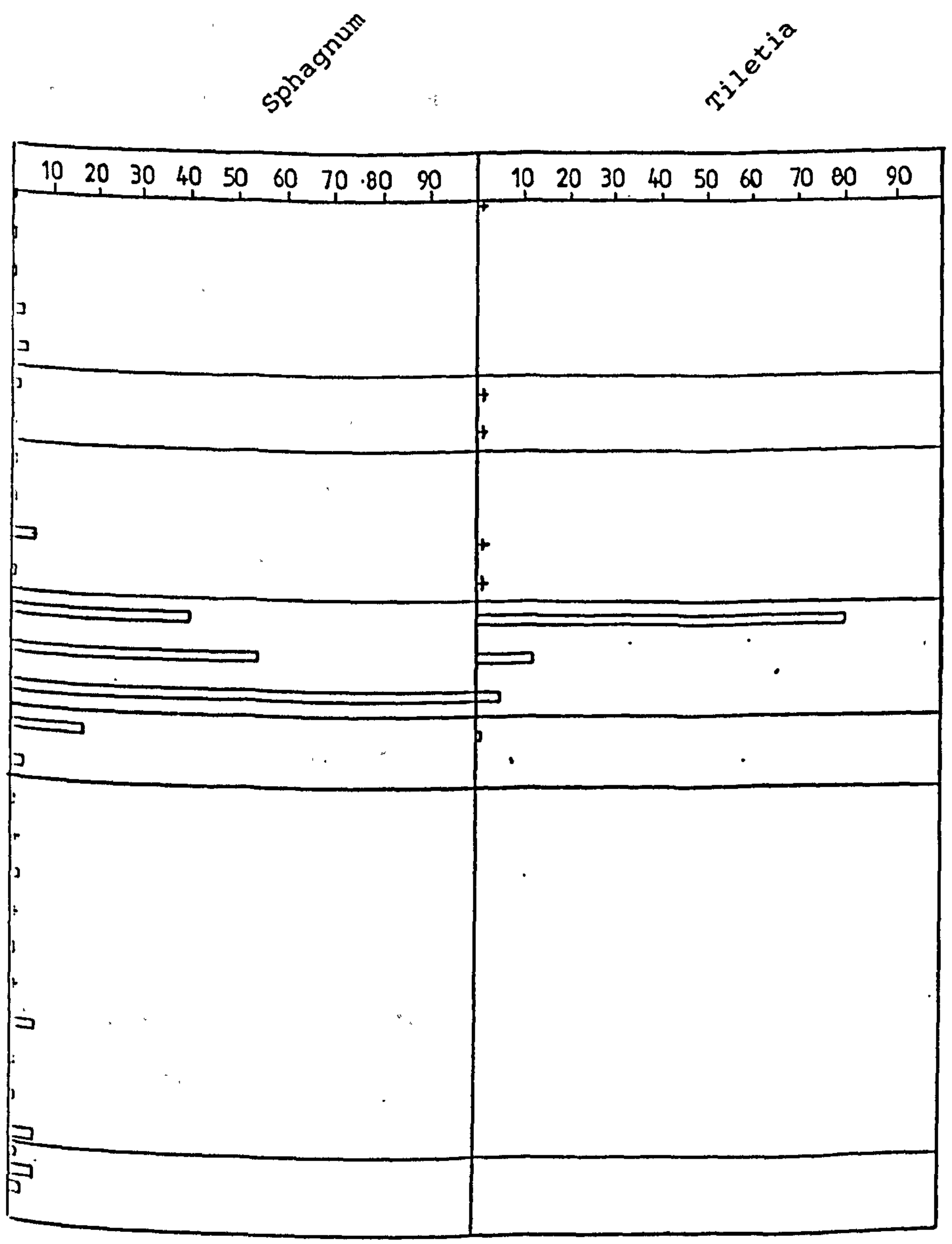
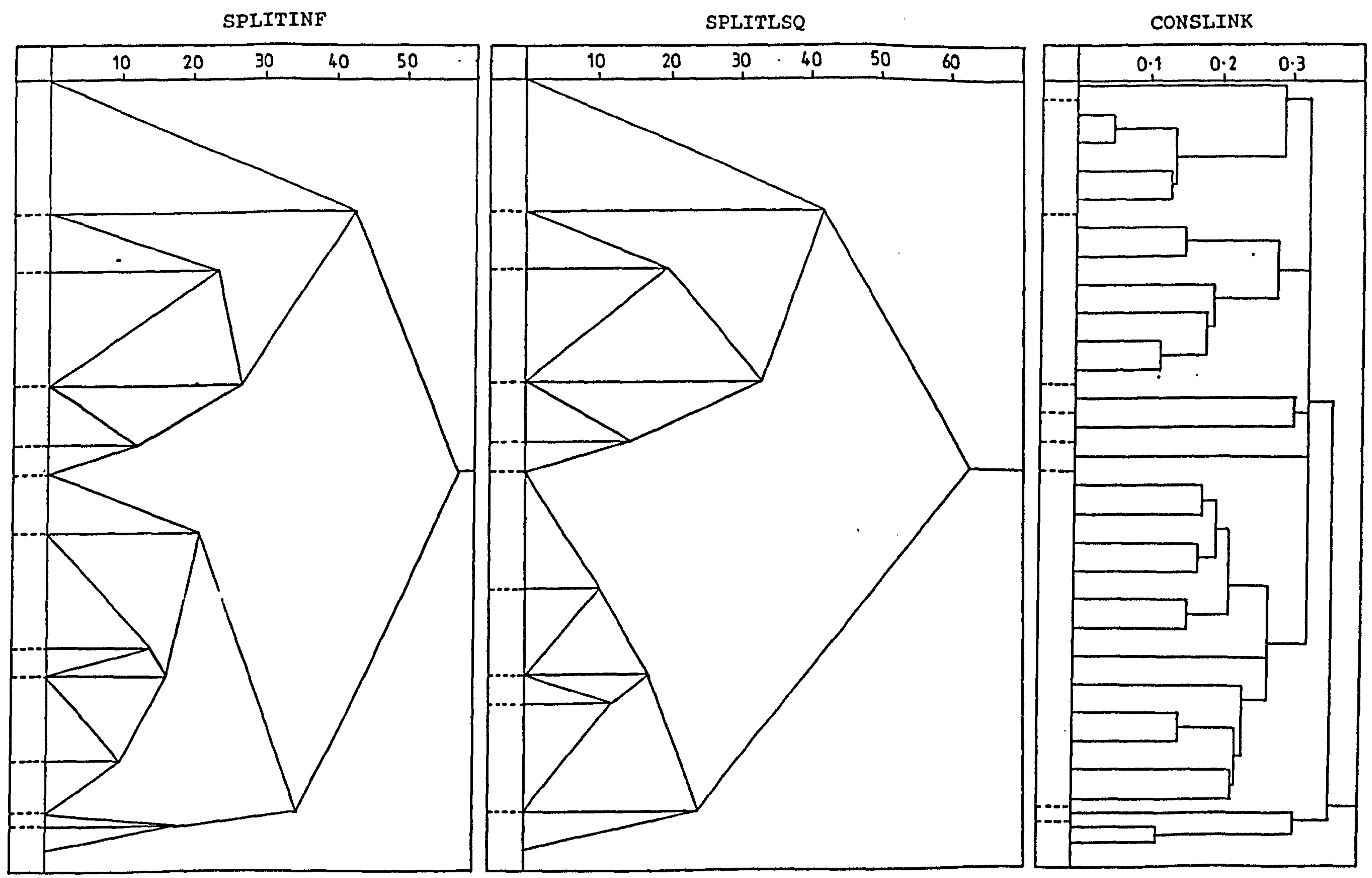


Fig. 4.18 BMP3 Results of the Zonation program.



DEPTH (cm)	POLLEN TYPE
0-1	*Abies, Rhododendron, Lythrum portula, Hydrocotyle*
8-9	*Rhamnus catharticus, Fagopyrum* type, *Populus*
16-17	*Ligustrum, Cannabis* type, *Gentiana pneumonathe*
20-21	*Abies*
24-25	*Ononis*
28-29	*Genista* type, *Athyrium filix-femina, Polygonum amphibium*
32-33	*Rubus, Serratula* type
36-37	*Abies, Aphanes* type, *Digitalis, Nymphaea*
40-41	*Ligustrum, Polygonum aviculare*
44-45	*Onobrychis* type, *Rubus, Ranunculus trichophyllus*
56-57	*Sorbus aucuparia, Juglans, Ranunculus arvensis, Rumex obtusifolius, Fagopyrum,* type *Cannabis* type, *Hydrocotyle*
60-61	*Juglans*
64-65	*Sorbus aucuparia, Ligustrum, Vaccinium, Helianthemum,* Leguminosae undiff.
68-69	*Vaccinium, Succisa pratensis*

Table 4.3. Pollen types found in BMP3 not included in the main pollen diagram.

72-73	*Lonicera, Spergula* type, *Solanum dulcamara*
76-77	*Solanum dulcamara, Rhinanthus* type
80-81	*Campanula* type
88-89	*Veronica* type, *Campanula* type, *Ranunculus trichophyllus, Mentha* type
96-97	*Sorbus aucuparia, Ononis* type
100-101	*Serratula* type

Table 4.3 cont.

Quercus, Corylus, Salix, Calluna, Erica, Potentilla, Rumex acetosa, Plantago lanceolata, Liguliflorae, Cyperaceae, Gramineae and *Pteridium.*

The results of these analyses are given in Figs. 4.17 and 4.18.

4.4.4 Local pollen assemblage zone descriptions.

Zone BMP3A. Depth 107-101.5cm

The split between sample numbers 26 and 27 is found to be significant by all the zonation programs. In fact, CONSLINK recognises this split as being the most important in the diagram. The DECORANA plot shows these samples forming a group associated with high axis 2 values. CONSLINK and SPLITINF split away sample no. 27 from the others in the zone. However, this is probably due to the isolated peak of *Salix* (13.5% T.P.) in this sample.

This zone is characterised by high numbers of arboreal and shrub pollen with low amounts of herbaceous taxa. *Corylus* is numerically the most important pollen type showing values between 21% and 35% T.P.. *Alnus* is the most common arboreal pollen type, and seen to increase during the zone to 25% T.P.. *Quercus* and *Betula* are both relatively important, but both fall during the zone to values less than 5% T.P.. The presence of *Tilia*, in numbers consistently above 1% T.P. should also be noted.

Gramineae and *Calluna* are the most important

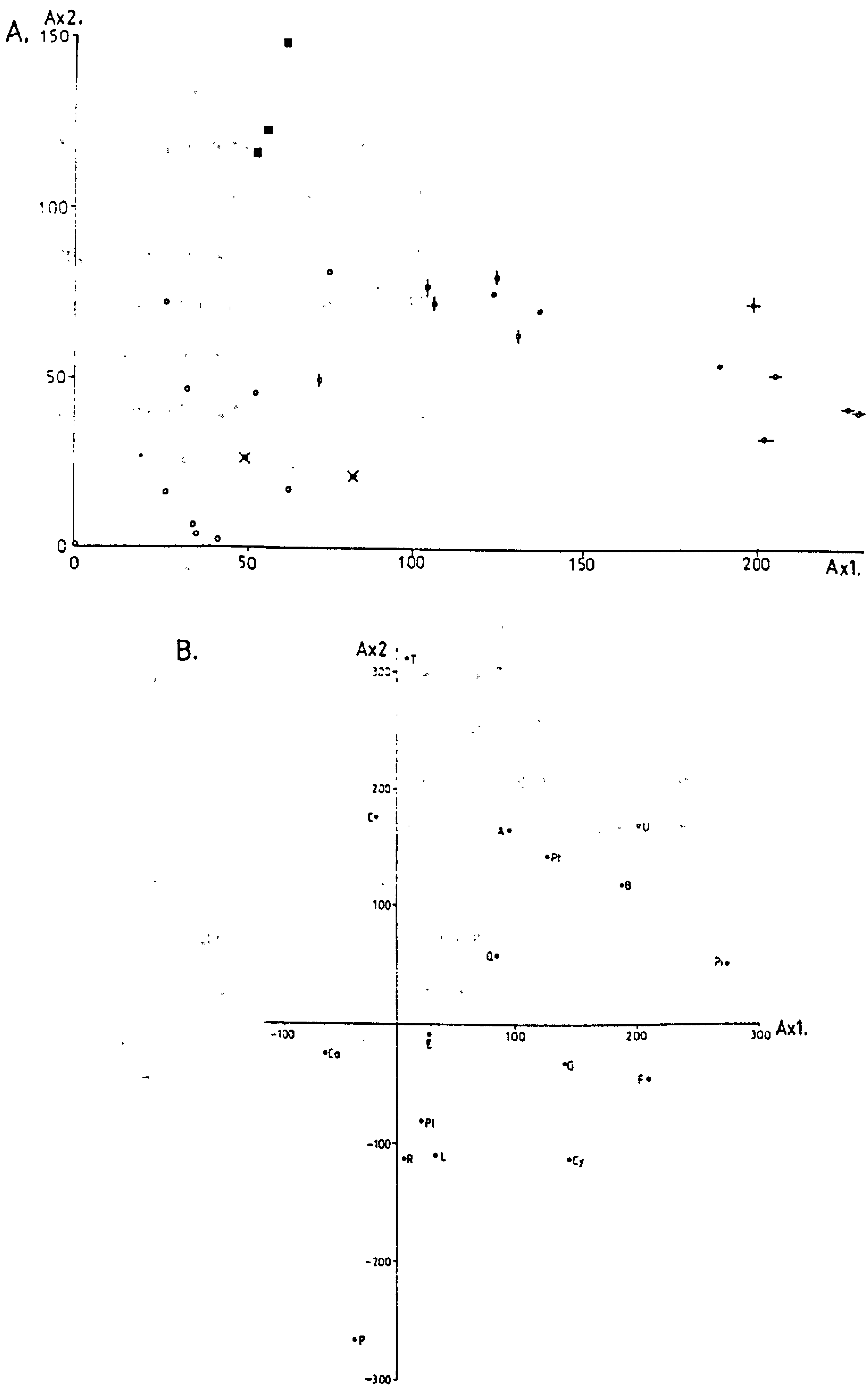


Fig. 4.17 BMP3-DECORANA A-Samples B-Species
(Key overleaf.)

Fig. 4.17 (cont.)

Key

A: Samples.

Assemblage zone BMP3A

o Assemblage zone BMP3B

Assemblage zone BMP3Ca

Assemblage zone BMP3Cb

Assemblage zone BMP3Cc

Assemblage zone BMP3Cd

Assemblage zone BMP3Ce

B: Species.

Pi- Pinus	Ca- Calluna
T - Tilia	E - Erica
U - Ulmus	P - Potentilla
B - Betula	R - Rumex acetosa type
A - Alnus	Pl- Plantago lanceolata
F - Fagus	L - Liguliflorae
Q - Quercus	Cy- Cyperaceae
C - Corylus	G - Gramineae
S - Salix	Pt- Pteridium

non-arboreal/shrub types present. Both are stable averaging 8% T.P..

Zone BMP3B. Depth 101.5-62cm

The boundary between zones BMP3B and BMP3C is mathematically not an important split; only SPLITINF gives it an significant value. SPLITINF, SPLITLSQ and to a lesser extent CONSLINK show a number of significant divisions within this zone, while the DECORANA plot shows these samples as a rather diffuse cluster, with a marked variation in their axis 2 scores. It is likely that all this is related to the fluctuations in the amounts of *Calluna* pollen seen in this zone.

The most striking evidence to support the placing of a zone boundary at the depth of 62cm is the change in the stratigraphy seen here, from well humified peat to unhumified *Sphagnum* peat.

This zone is dominated by dwarf shrub and herbaceous pollen types. *Calluna vulgaris* is the most important pollen type present. However it also shows the most variation, falling in importance in the middle of the zone. It shows a range of values between 8% and 60% T.P..

Not only are higher numbers of herbaceous pollen seen in this zone, but a greater number of taxa are represented. Gramineae is the most frequent herbaceous pollen type and after increasing at the start of the zone, remains fairly constant, averaging 22% T.P.. Other important herbaceous pollen types include *Plantago lanceolata, Rumex acetosa* and Liguliflorae type.

Corylus is variable in this zone, with a range of values between 4% and 26% T.P. . *Quercus* is relatively stable throughout the zone, averaging 9% T.P., while *Alnus* varies between 3% and 18% T.P.. *Betula* also shows no definite trends, fluctuating between 2% and 8% T.P..

Zone BMP3C. Depth 63-0cm

It was decided to treat the upper portion of the diagram, above the change in stratigraphy, as a single zone with five subzones. Generally this zone is dominated by arboreal pollen types, the different sub-zones reflecting the changes in the spectrum of the arboreal pollen types present. Mathematically the upper boundary of sub-zone BMP3Ca, the split between sample nos.14 and 15, is the most important. SPLITINF and SPLITLSQ both assign it the highest values seen in this core; CONSLINK values it of joint second importance. However, the samples of BMP3Ca are mathematically seen as being very similar to the members of zone BMP3B. This is reflected in the DECORANA plots for these samples.

The upper boundary of sub-zone BMP3Cb, between samples 11 and 12, is significant in all the zonation programs. Sample 14 is split off from the rest of this sub-zone by the zonation programs. This can be seen to be because of the 44% T.P. peak in *Pinus* pollen seen in sample 14. This peak must be an important factor influencing the importance of the split between this sample and sample 15. The DECORANA plot for sub-zone BMP4Cb, shows this sample lying away from the other members of this group, being closer to the members of zone Cc.

The upper sub-zone boundary for BMP3Cc, between samples 7 and 8, is also found to be significant by all the zonation programs. This group also forms a close grouping on the DECORANA plot. Again all the zonation programs see the upper boundary of sub-zone BMP3Cd, between samples 5 and 6 as being significant. The DECORANA plot assigns these two samples onto the same point. It can also be seen they are relatively closely related to the members of sub-zone BMP3Cc. The samples in sub-zone BMP3Ce are associated with samples 12 and 13 of zone Cb on the DECORANA plot. It is also interesting to note the proximity of sample 1 on the DECORANA plot to those members of zone BMP3B.

The descriptions of these sub-zones are as follows:

Sub-zone BMP3Ca. Depth 62-55cm

Although the pollen spectrum of this sub-zones is similar to that of zone BMP3B, there are a number of differences. The first is the appearance of significant amounts of *Pinus*, averaging 2.5% T.P.. *Alnus* has increased appreciably from the previous zone, to an average of 15.5% T.P.; while *Corylus* has become much less important averaging only 4% T.P.. Outside the pollen sum, we see an increase in the numbers of *Sphagnum* spores.

Sub-zone BMP3Cb. Depth 55-42.5cm

This sub-zone is characterised by increases in *Pinus* and *Betula*. As previously mentioned *Pinus* peaks at 44% T.P. while *Betula* shows a maximum value of 22% T.P.. *Alnus* increases slightly during the sub-zone to 27% T.P.. *Quercus* remains relatively unchanged, while it should be noted that it is in this sub-zone we first see the regular appearance of small amounts of *Castanea* pollen. *Corylus* fluctuates in this sub-zone, peaking at 10% T.P., while otherwise remaining at or below 2%T.P..

The amounts of *Calluna* pollen fall dramatically to an average of 2.5% T.P.. The percentages of herbaceous taxa, and even the number of different herbaceous pollen types present are seen to fall in this sub-zone. Gramineae is still the most important herbaceous pollen type present, but it has fallen to an average of 15% T.P.. Cyperaceae is relatively numerous, achieving a maximum of 7% T.P.. High numbers of *Sphagnum* spores are seen during this sub-zone, peaking early and then dropping, but it is of interest to note that this drop in *Sphagnum* is accompanied by an increase in spores of the fungus *Tilletia*, a parasite of *Sphagnum*.

Sub-zone BMP3Cc. Depth 42.5-26.5cm

There is a significant increase in *Pinus* at the beginning of this sub-zone, achieving a maximum of 70% T.P.. This rise in *Pinus* is accompanied by falls in the numbers of most of the other taxa present. *Betula* and *Quercus* both drop to 2% T.P. , then increase slightly. *Alnus* falls to an average of 3% T.P.. While *Corylus* and *Calluna* never rise above the value of 3% T.P.. Gramineae is an exception to this trend, showing an average value of 17% T.P.. The numbers of *Sphagnum* spores fall away dramatically in this sub-zone.

Zone BMP3Cd. Depth 26.5-18cm

This sub-zone is characterised by a sharp rise in *Betula* pollen, reaching 31% T.P.. *Pinus* falls to around 40% T.P.. Little else changes significantly, except Gramineae which drops on average to around 10% T.P..

Sub-zone BMP3Ce. Depth 18-0cm

The most important feature of this zone is the drop in *Pinus*. It falls initially to 9% T.P., dropping further by the end of the diagram. The amounts of *Betula* remain important: they are stable, averaging 28% T.P.. *Alnus* increases slightly to an average of 9% T.P.. *Quercus* also is seen to increase slightly; it shows an average value of 6.5% T.P. Both *Corylus* and *Calluna* increase markedly through this sub-zone, to 16% T.P. and 21% T.P. respectively, by the top of the diagram. The amounts of Gramineae are generally stable, but are higher than the previous sub-zone, averaging 18% T.P..

4.4.5 ^{14}C Analysis

Five samples were selected for analysis from this core. They were as follows:

1. SRR-3420 This sample was taken from the monocot peats at the depth of 100-107cm below the present surface. It

gave a date of 2910 ± 65 years B.P..

2. SRR-3419 This sample was taken from the monocot peats at the depth of 63-70cm below the present surface. It gave a date of 340 ± 65 years B.P..

3. SRR-3418 This sample made up of the *Sphagnum* peats from the depth of 50-60cm below the present surface gave a 'modern' date.

4. SRR-3417 This sample made up of the *Sphagnum* peats from the depth of 25-31cm below the present surface gave a 'modern' date.

5. SRR-3416 This sample made up of the *Sphagnum* peats from the depth of 13-23cm below the present surface gave a 'modern' date.

The position and ages of these samples are also shown on the main pollen diagram (Fig. 4.16).

4.4.6 Local Pollen Assemblage Zone Interpretation.

Zone BMP3A.

This zone was totally included in the ^{14}C dated sample that gave a date of 2910 ± 65 years B.P.. This demonstrates that this assemblage zone dates from the Bronze Age. As this pollen assemblage predominantly consists of arboreal and shrub taxa, it can be assumed that a largely woodland system is represented here. Andersen (1970) suggested that in a closed canopy situation most of the pollen in surface samples was derived from within a radius of 20-30m of the sampling site. Andersen, in the same paper, also proposed a set of correction factors for arboreal pollen types that takes into account differences in pollen production and dispersal between different species. These factors can be used to estimate the canopy cover of different arboreal species in the immediate area of the sampling site from fossil pollen spectra. However they are only reliable for small sites within a forest. Fig. 4.19 shows the results of applying these correction factors to the arboreal pollen spectra of this assemblage zone.

A mixed deciduous woodland is represented. *Alnus* is the most numerous species, *Quercus* and *Tilia* also being important. Considering the topography of this site, the most reasonable interpretation of these results is that the alder was growing in the lower, presumably wetter, parts of the valley, possibly in carr conditions, while the lime and oak were growing on the drier valley sides.

However, the fact that *Corylus* is the most numerous pollen type in the overall pollen assemblage must be taken into account (see Appendix 1). The values of *Corylus* show that the species is flowering readily. This suggests that there are gaps in the canopy of the other trees thereby allowing heavier flowering of the *Corylus*, or possibly areas of *Corylus* coppice are present.

The presence of significant amounts of *Calluna*, and the occurrence of *Plantago lanceolata* pollen in this assemblage, both light demanding species, add evidence to the theory that there are gaps in the woodland canopy. The records of *Plantago lanceolata* suggest that such clearings could be kept open by grazing pressure. Gaps in

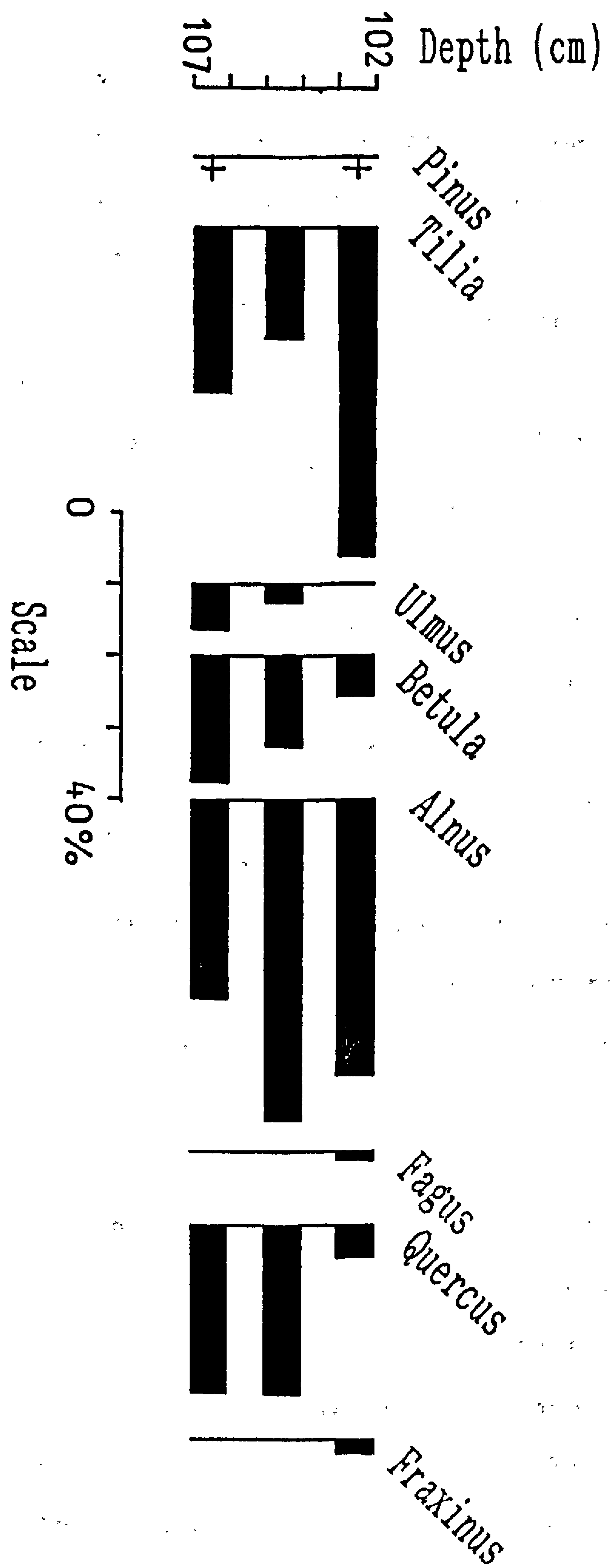


Fig.4.19 - BMP3A Adjusted Arboreal Pollen Diagram.

(Values expressed as percentages of adjusted arboreal pollen sum.)

the canopy cover also help to explain the amounts of *Betula* present, since this genus could become established in open areas.

It is possible that the sampling site may have been under an open canopy. The fact that the sediments at this point consist of peats suggest that a valley bog occupied the site then, as it does today. If the canopy was open above the actual sampling site, there are a number of implications for the size of the site's pollen catchment area. The pollen spectrum from under such an open area in the forest canopy will reflect the vegetation of a larger area than would an assemblage from under a closed canopy. Andersen (1970) stated that in pollen assemblages from open areas within a woodland, trees with light pollen grains such as *Pinus, Betula, Quercus* and Alnus could be over-represented even in corrected tree pollen spectra as they have a larger source area than other trees. Other taxa, such as *Tilia*, therefore will be under-represented in spectra from these areas, even in corrected diagrams.

Zone BMP3B.

A drop in the values of arboreal species together with an increase in ericaceous and herbaceous pollen types suggests that the beginning of this zone is marked by a clearance of at least part of the local woodland, opening up the canopy cover in the area. The boundary between zones BMP3A and BMP3B is included in the ^{14}C dated sample of age 2910 ± 65 years B.P.. It must be therefore assumed that the clearance seen at the beginning of this zone was at the hands of Bronze Age people. The ^{14}C dated sample taken from the upper part of this zone gave a date of 340 ± 65 years B.P.. This suggests that this assemblage zone continued until the early seventeenth century. Assuming the sediments of this zone are complete (there are no apparent breaks in the stratigraphy) then BMP3B can be seen to cover a time period of over 2500 years in a depth of around 40cm. This indicates that the sedimentation rate must have been relatively slow. This would be consistent with the well humified nature of the peat making up this zone.

Alnus, Tilia and *Ulmus* appear to be the arboreal taxa most affected by the woodland clearance. The fact that there is little change in the percentages of *Quercus* present may be merely a reflection of the change in pollen catchment area. If, as appears to be case, the canopy of the area has been opened, a greater amount of non-local pollen will be incorporated into the sediment. *Quercus* is one of the pollen types Andersen (1970) stated as having potentially a large source area, so the amount present in the assemblage could reflect the level of its occurrence regionally rather than its importance locally. As far as the regional arboreal spectrum is concerned the increased abundance of *Fagus* and *Fraxinus* towards the top of this zone could be important. Both these pollen types were found by Andersen (1970) to be under-represented in pollen diagrams, even under closed woodland canopy conditions. It is therefore possible that these low amounts deposited in relatively open conditions could indicate that these species comprise a considerable proportion of the regional woodland.

Corylus is still important at the start of this zone, one of the most important members of the pollen spectrum together with *Calluna* and Gramineae. Tinsley and Smith (1974) found that occurrence of *Corylus* values of above 20% total pollen in spectra dominated by non-arboreal taxa, may suggest that this species is present locally in significant numbers. Although their studies were carried out on upland moorland in Yorkshire, and therefore comparisons with it must be cautious, a sample in this part assemblage zone contains *Corylus* at a value above 20% total pollen. This therefore raises the possibility that rather than the clearance episode leading directly to open heath, the local vegetation could have been initially a *Corylus*/grass-heath mosaic such as that found by Dimbleby (1962) in the transition from woodland to pure heath. The fall in *Corylus* seen towards the middle of the assemblage zone is a reflection of the reduction in shrub cover.

The rise in *Calluna* and *Erica* values shows that a heathland type of vegetation now became established in the area. The degree of importance of *Erica* in the heathland is more difficult to establish as this is a lower pollen producer than *Calluna* and will therefore be under-represented in the pollen spectra. *Vaccinium*, another dwarf shrub associated with heaths is also represented in this assemblage.

There are relatively large amounts of Gramineae present and, as Behre (1981) pointed out, this pollen type is commonly associated with heathland habitats. Other pollen and spore types present which Behre also suggested were strongly associated with heathland are *Campanula* type, *Rumex acetosella* and *Pteridium*. Many other pollen types Behre thought to be less closely associated with heathland are also present, for example *Succisa pratensis* and Liguliflorae types. If the *Potentilla* type pollen is derived from *P.erecta*, another species associated with heathland, its increase in importance towards the top of the zone could indicate an increase in the intensity of grazing in the area.

The general increase in representation of herbaceous pollen types is probably a reflection of the removal of canopy cover together with an increase in the size of the pollen catchment area. The increase in the size of the catchment is possibly illustrated by the record of *Helianthemum* which is a species of basic/chalk habitats. The fact that, other than Gramineae, *Plantago lanceolata* is the most numerous herbaceous pollen type is noteworthy. This is not a pollen type strongly associated with heathland. Behre (1981) states that this species is absent on heaths on dry sandy soils. *Plantago lanceolata* however does show high pollen dispersal, so its presence in the spectrum may reflect a degree of pastoral farming regionally. It should be noted that there are records of possible cereal pollen grains, and of *Spergula arvensis*, a weed of arable land, in this zone. These pollen types are poorly dispersed so this suggests that any arable activity is probably close to the sampling site.

Although *Calluna* is generally the most numerous pollen type in this zone it does fall in importance around the middle of this zone. Work by Evans and Moore (1985) showed that in surface samples the percentage of *Calluna* pollen in the assemblage is strongly correlated with the amount of *Calluna* cover in the immediate area of the sampling site. However, if one considers the apparently slow accumulation rate of the peat making up this zone, it would appear that the low levels of *Calluna* persisted for far longer than would be expected if they were due to a temporary drop in *Calluna* cover in the vicinity of the sampling site. The drop in *Calluna* is also accompanied a fall in the frequency of *Plantago lanceolata* and by increases in *Betula, Alnus, Quercus* and *Corylus*. This suggests that there could have been a lapse in the management of the heath allowing some degree of re-establishment of the trees, and also a drop in the importance of agriculture. It is possible that this event represents a post-Roman decline in land use in the area (a Roman villa is located within a few kilometres of the site at Bignor). However, due to the length of time that this assemblage zone apparently covers, it is not easy to be specific about the internal chronology of the zone.

The amounts of *Calluna* do increase again towards the end of the zone, as do those of *Plantago lanceolata* which suggests land use increases again towards the end of the zone, possibly in the early medieval period. It is in this period that *Spergula* is recorded, the firmest indicator of arable agriculture present in this assemblage zone.

Zone BMP3C.

To explain the change in sediment type seen at the boundary between this and the previous zone, either one of two hypotheses is likely. Firstly the peat at the site may have been cut down to the level of the boundary between BMP3B and BMP3C. Two samples ^{14}C dated from just above and just below the boundary, give dates of modern and 340 ± 65 years B.P. respectively. Given the slow rate at which the lower peats seem to have accumulated and the range of time the ^{14}C dating may actually indicate, these dates can be seen as rather inconclusive in establishing whether the peat has been cut. One has to be especially cautious about the 340 years B.P. date, as it is possible that the sample used to determine this date could possibly be contaminated with materials from above, such as rootlets which would increase the proportion of modern carbon in the sample. Another factor to consider is that if the lower peats did build up at a slow rate and their upper levels date from the early seventeenth century, or later, then the amount of peat that could have formed above this point would not seem to have been worthwhile removing.

The other possibility is that a change in the local hydrology caused changes in the type of peat and the rate at which it formed at this site. Again the results from the ^{14}C dating possibly throw light on this hypothesis.

The date obtained for the upper peats of the previous zone, 340 ± 65 years B.P., is very close to the ^{14}C sample, SRR-3414, from core BMP2 which was dated at 330 ± 65 years B.P.. This sample was taken from the point in time where the level of the mill pond was raised, probably in conjunction with the establishment of an iron forge at the site. This would suggest that a change in the local hydrology did take place around this time. *Sphagnum* was able to expand in the site, as witnessed by the change in the nature of the peats and the high numbers of *Sphagnum* spores in the lower portion of this zone, which is consistent with a rise in the water table.

All the ^{14}C dates from within this zone; SRR-3416, SRR-3417 and SRR-3418 give modern dates. Apart from indicating that all the events seen in this zone are quite recent, they also suggest that the sedimentation rate is considerably faster than that seen in the previous zone.

As this zone is largely dominated by arboreal pollen, suggesting that a closed tree canopy was present during most of the period covered by the assemblage, a corrected arboreal pollen diagram is given for sub-zones BMP3Cb-3Ce (Fig. 4.20). This diagram is based on the correction factors given by Andersen (1970). However, *Castanea* is present in this assemblage but was not included in Andersen's study, so it was decided to assign this species a correction factor estimated on the basis of the similarities between its floral biology and those of the taxa studied by Andersen. Hence it was assigned

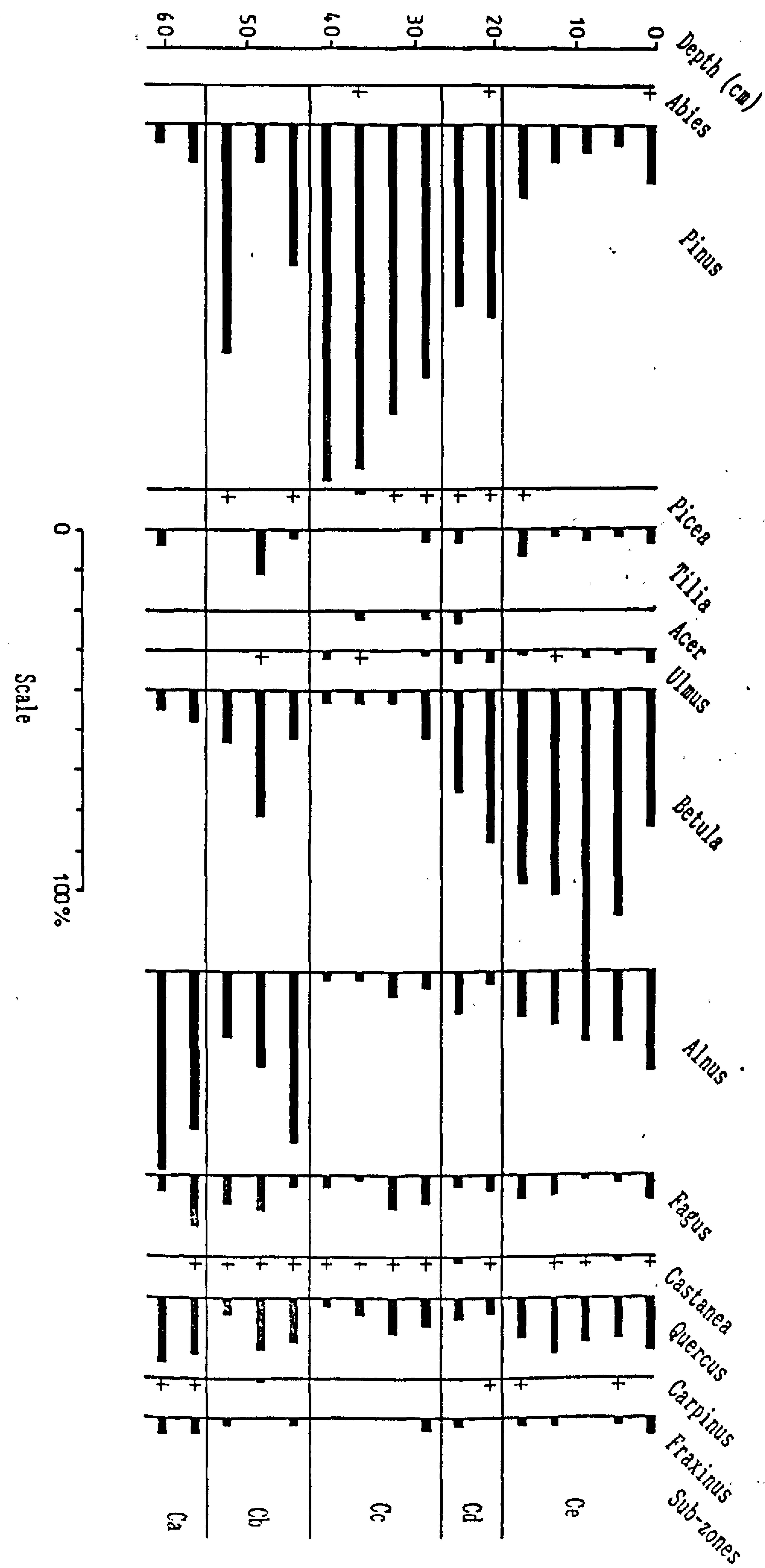


Fig. 4.20 - BMP3C Adjusted arboreal pollen diagram .

(Values expressed as percentage of adjusted arboreal pollen sum.)

the correction factor 1:4, as this species is wind pollinated, having long pendulous male catkins and high pollen productivity and is therefore similar to species such as *Alnus* and *Betula*.

Sub-zone BMP3Ca.

The general similarity between this pollen assemblage with that of the previous sub-zone suggests that the vegetation of the immediate area is still heathland. However, the differences between the two assemblages are important. The increase in *Pinus* pollen shows that this tree is now more important locally. The increase in *Alnus* suggests that the exent of the alder carr near this site has increased, again probably due to the change in local hydrology. This might be expected, as evidence from ^{14}C dating of this core and BMP2 suggests that the Mill Pond was extended around the time of the beginning of this zone. The increase in Cyperaceae may also be a reflection of the wetter condition of the sampling site or the proximity of the mill pond.

The drop in the numbers of *Corylus* pollen in this assemblage suggests that this species has become much less important, or at least not flowering as heavily.

The herbaceous spectrum associated with this sub-zone is of note as it contains a number of agricultural indicators. Apart from pastoral indicators such as *Plantago lanceolata* and *Rumex* spp (present through the zone as a whole), indicators of arable agriculture are also present. *Fagopyrum* and *Cannabis* type could represent actual crop plants, while *Ranunculus arvensis* was formerly a common weed of corn fields. Also, as discussed in relation to the first of the cores taken from the Mill Pond, the records of *Juglans* could be an indication of local inhabitation.

Sub-zone BMP3Cb.

In this sub-zone the start of a drastic change in the local vegetation is seen. The rise in *Betula* and *Pinus* suggests that these species are becoming established on the heath and starting to form secondary woodland. This implies there has been a change in management of the heath; probably the level of grazing on the heath has dropped, and this has allowed these tree seedlings to become established. It is also possible that other factors such as the cessation of heath cutting or changes in the intensity of fire management could be responsible for the change.

The regular appearance of *Castanea* in the assemblage could signal the establishment of the area of sweet chestnut coppice seen near the sampling site today. This area was almost certainly planted, as the spontaneous invasion of this large-seeded species is relatively doubtful.

Alnus is still relatively important in this assemblage, and it is probably derived from the wetter areas around the pond margin rather than close to the sampling site. This implies that the tree canopy around the sampling site is not yet fully formed and pollen from distances greater than 30m is reaching the sampling site.The record of *Onobrychis*, a species of chalk habitats helps to confirm this. This suggests the Andersen's correction factors are not strictly applicable to this subzone, because, as mentioned earlier, under open conditions tree species such as *Pinus* and *Betula* whose pollen is well dispersed will tend to be over-represented, while poorly dispersed species will be under-represented, even in corrected diagrams (Andersen, 1970).

Although it would seem that a full tree canopy has not yet formed at the site, the drop in the numbers of herbaceous pollen does imply an increased degree of shading locally. It is possible that changes in grazing patterns may also contribute to this.

Sub-zone BMP3Cc.

This sub-zone shows the next step in the secondary woodland development. Although *Betula* and *Pinus* first colonised the heath together, *Pinus* has now matured, suppressing the *Betula* and thus following the subspontaneous *Pinus* woodland succession described by Tansley (1939). It is probable that a dense tree canopy dominated by *Pinus* covered the area around the sampling site at that time. The presence of tree stumps on the valley bog today adds weight to this. As mentioned previously this implies that most of the pollen in this assemblage was derived from within 20-30m of the sampling site (Andersen, 1970) and that his correction factors are now applicable. This decrease in the size of the pollen catchment explains the fall in the other arboreal taxa. However, the corrected diagram suggests that *Quercus* and *Fagus* might have played a minor role in the local woodland. The first record of *Abies* in the diagram is seen in this sub-zone; it is possible that the presence of the pollen of this introduced taxon could indicate the start of plantations in the region.

The fall in *Calluna* would also be expected as, even if this species were not totally suppressed under the *Pinus* canopy its flowering would be seriously impaired.

The fact that Gramineae has remained at similar values to those seen before the rise in *Pinus* is more difficult to interpret. Either Gramineae spp. were important in the herb layer and were able to flower, or this pollen type is either derived from local *Molinia*, as seen at the site today, or from nearby pastoral or fallow fields. *Plantago lanceolata*, the only other common herbaceous pollen type is probably derived from nearby pastoral land.

The fact that *Pteridium* spores are still relatively frequent suggests that plants of this species have survived the forestation of the heath and now form part of the ground layer.

The dramatic drop in the numbers of *Sphagnum* spores must be due to factors affecting sporulation, possibly caused by the establishment of the pine, such as shading or a decrease in water availability, as the stratigraphy provides evidence that these mosses were still present at the site.

Sub-zone BMP3Cd.

The rise in *Betula* is either explained by this species becoming established under gaps in the *Pinus* canopy in the area or by a partial clearance of *Pinus* which then allowed *Betula* to become re-established. The corrected pollen diagram suggests that between them they made up over 70% of the canopy cover locally.

As both *Betula* and *Pinus* are very high pollen producers (Andersen, 1970; Bradshaw, 1981), the non-arboreal components in this pollen spectrum will be under-represented. Unfortunately no work has been done on correction factors to allow for this.

Sub-zone BMP3Ce.

The dramatic drop in the value of *Pinus* that marks the beginning of this sub-zone must reflect the clearance of much of the pine from the local area, including the trees formerly growing over the valley mire. This event indicates the development of the vegetation pattern of the site as it is today with *Betula* rising to dominance. However, as there are birch as well as pine stumps on the valley bog today, it is evident that some birch was also cleared at this point in time. The canopy cover over the sampling site was removed at this point, which is reflected in a number of ways. Firstly *Calluna* and *Erica* can be seen to increase in importance, reflecting the bog surface vegetation seen today, in response to the more open conditions. The record of *Gentiana pneumonathe* is of interest here, as this is also a species associated with wet heath.

The rise in *Corylus*, a species not abundant nearby today, reflects the fact that there is a larger pollen catchment area resulting from the opening up of the canopy cover. The rises in *Alnus* and *Quercus* will also be due to this effect. The opening of the canopy also suggests that the correction factors will now be underestimating the importance of trees with low pollen production and dispersal (Andersen,1970), so correction factors become less reliable.

Other pollen types present in this sub-zone that are worthy of mention are *Cannabis* type and *Fagopyrum*, indicators of arable agriculture. The record of *Rhododendron* in the uppermost sample is a reflection of the increasing importance of this species at the site today.

4.5 Burton Mill Pond Core 4 (BMP4)- Mor Humus/soil Core.

This monolith was taken from a small area dominated by oaks in the Newpiece area of the Nature Reserve, close to the small valley mire (see Fig. 4.2.).

4.5.1 Stratigraphy.

0- 7.5cm-'F1' layer, compacted, laminated leaf litter
7.5- 9.0cm 'F2' layer
9.0-21.0cm 'H' layer
21.0-33.0cm A1 layer
33.0-42.0cm A2 layer
42.0-43.5cm Dark humic sand
43.5-46.5cm Lighter sand.

4.5.2 Pollen Stratigraphy.

The soil monolith was sampled contiguously every 1.5cm. A minimum of 500 pollen grains were counted form each sample. Both the summary diagram (Fig. 4.21) and the main pollen diagram (Fig. 4.22) for this core were constructed using the data expressed as percentages of total pollen and spores (T.P.). Pollen types found in BMP4 but not shown on the main pollen diagram are given in Table 4.4.

4.5.3 Numerical Analysis.

The pollen types used in numerical analysis of the data were: *Pinus*, *Betula*, *Alnus*, *Castanea*, *Quercus*, *Corylus*, *Calluna vulgaris*, *Erica*, *Anemone*, *Plantago*

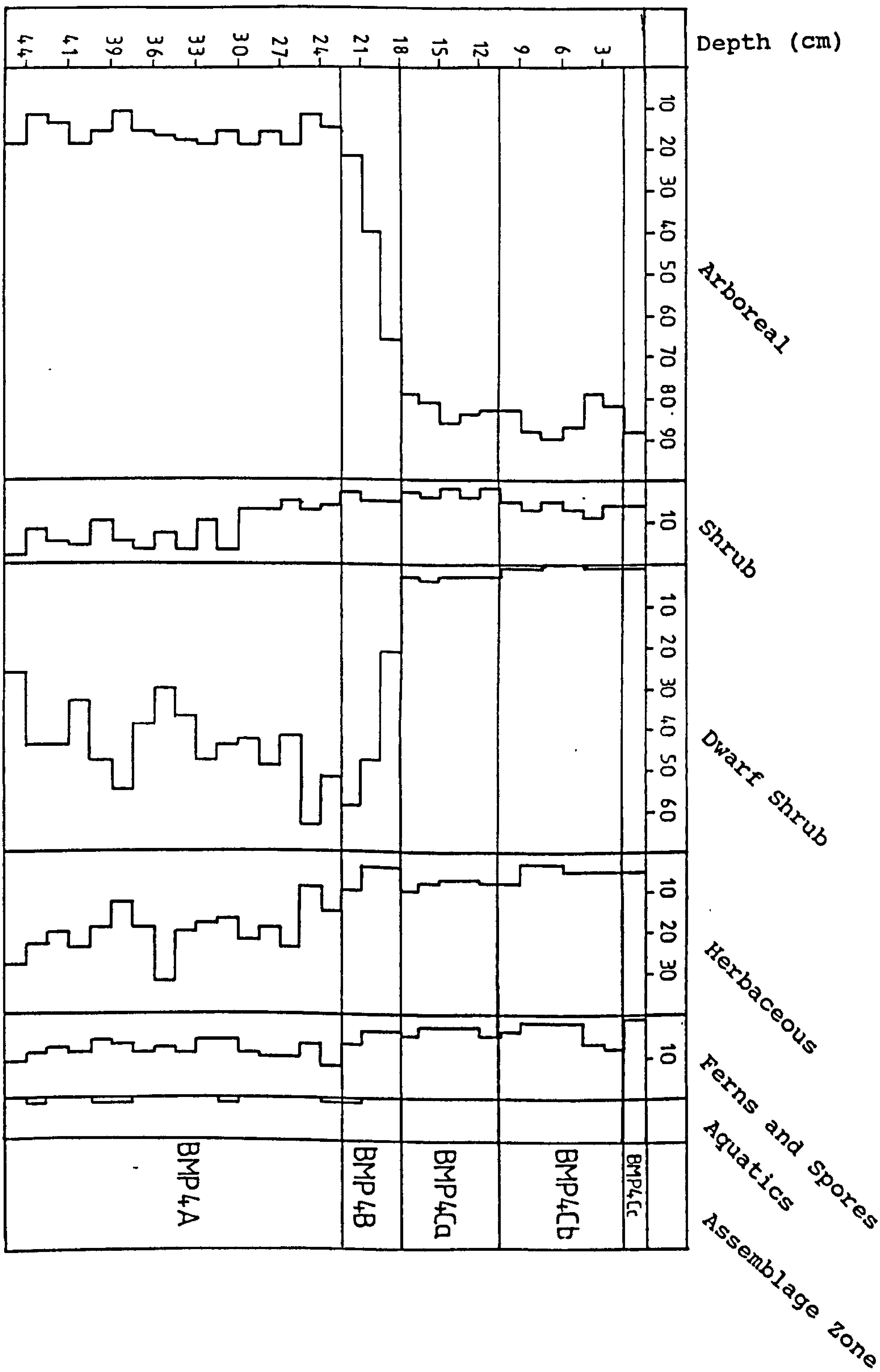
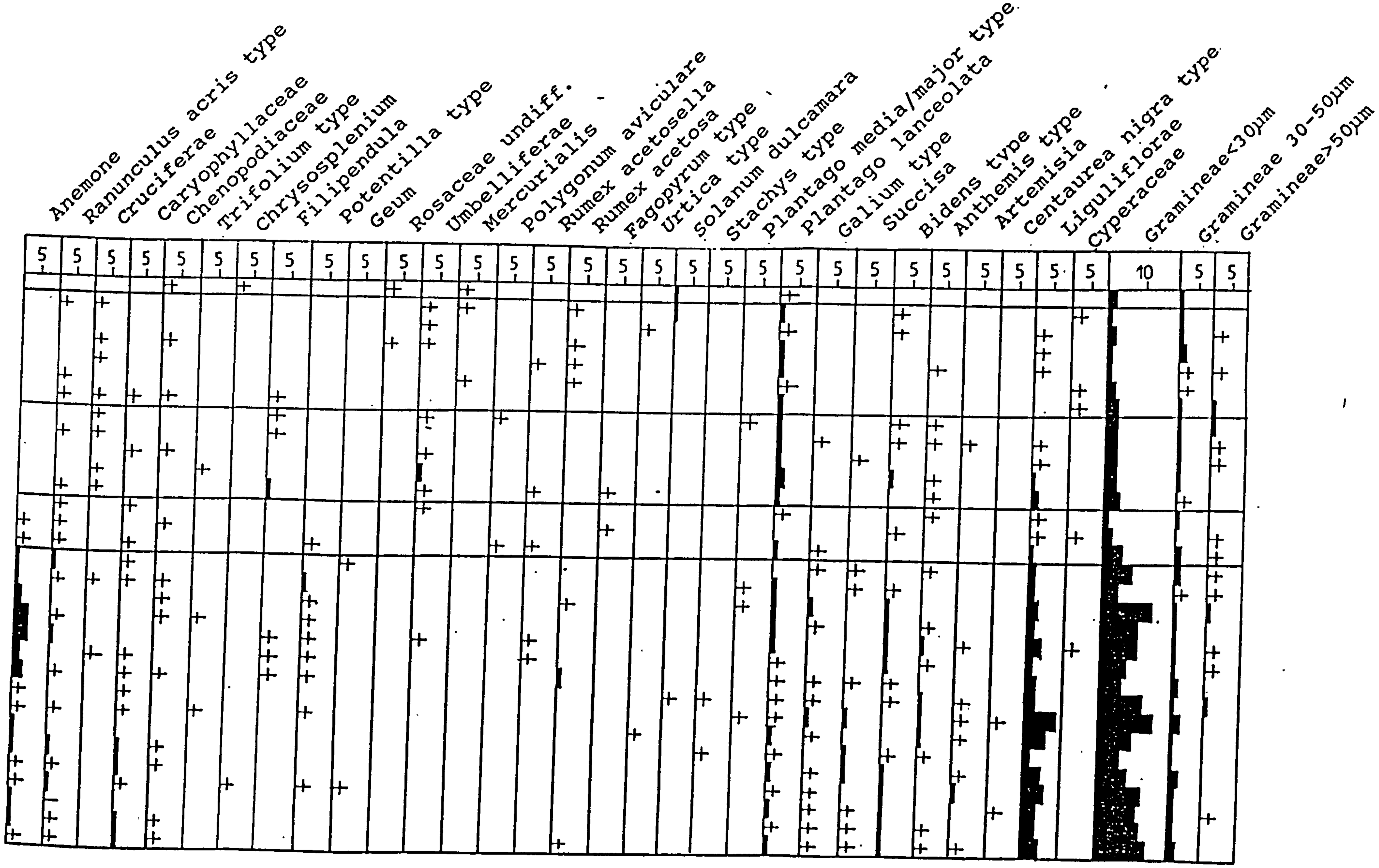


Fig. 4.21 BMP4 - Summary Pollen Diagram.

(Values expressed as percentages of the sum of total pollen and spores.)

Fig. 4.20 BMP4 - Main Pollen Diagram
All values expressed as percentages of the sum of total pollen and spores.(+ represents values <1%)

Fig. 4.20 Cont.



Anemone
Ranunculus acris type
Cruciferae
Caryophyllaceae
Chenopodiaceae
Trifolium type
Chrysosplenium
Filipendula
Potentilla type
Geum
Rosaceae undiff.
Umbelliferae
Mercurialis
Polygonum aviculare
Rumex acetosella
Rumex acetosa
Fagopyrum type
Urtica type
Solanum dulcamara
Stachys type
Plantago media/major type
Plantago lanceolata
Galium type
Succisa
Bidens type
Anthemis type
Artemisia
Centaurea nigra type
Liguliflorae
Cyperaceae
Gramineae<30μm
Gramineae 30-50μm
Gramineae>50μm
5
10

Fig. 4.20 Cont.

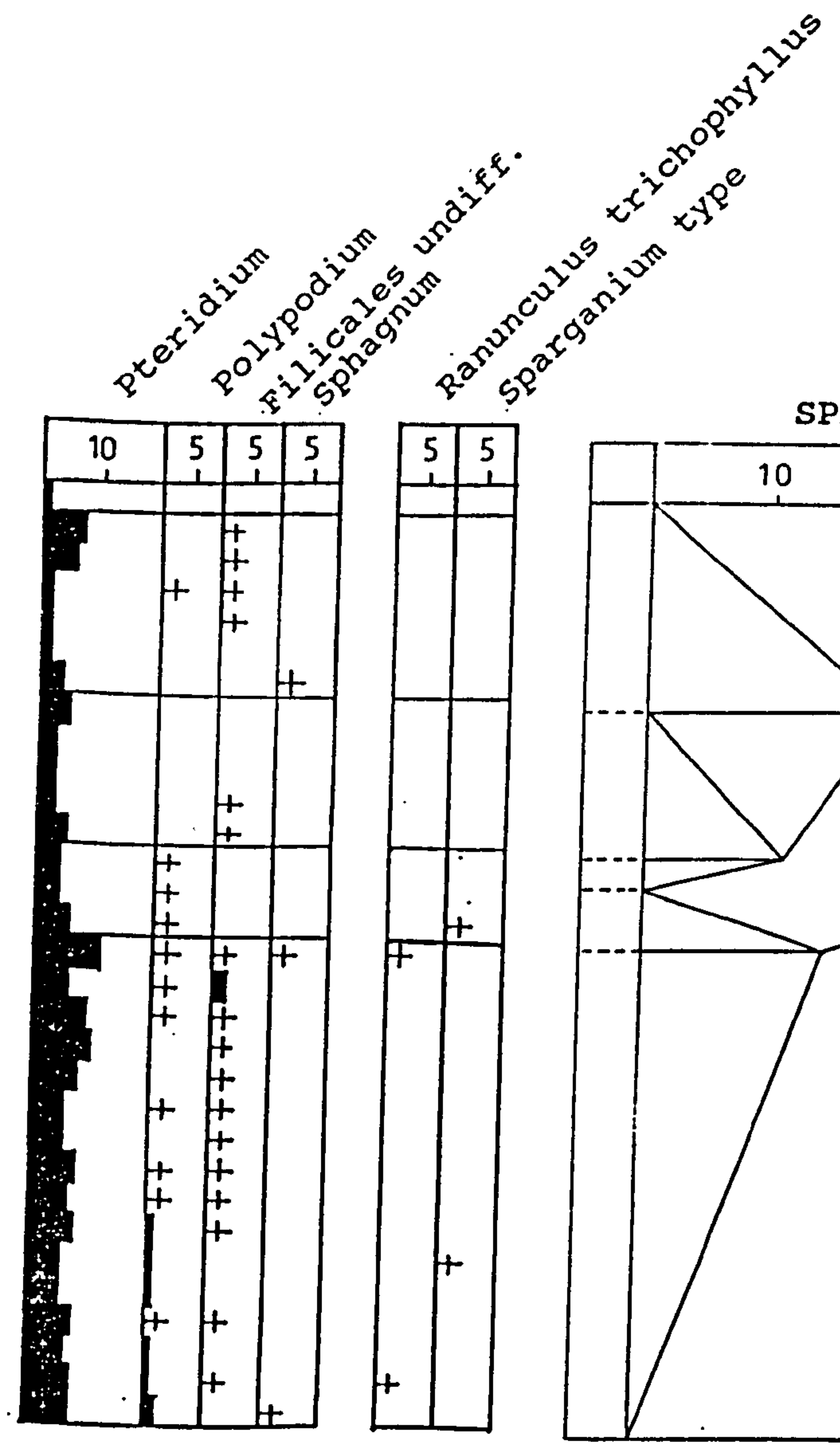
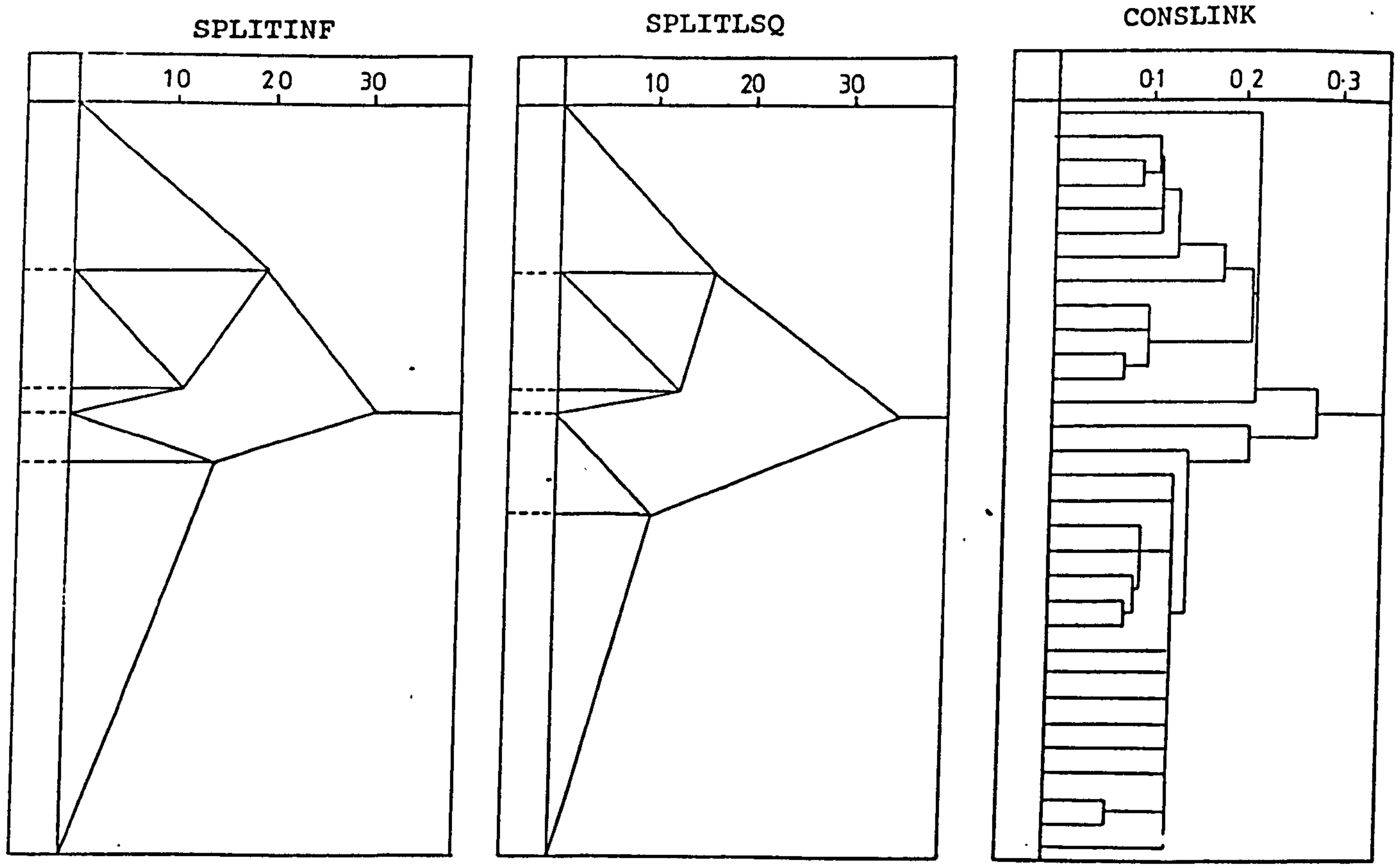


Fig. 4.24 BMP4 Results of the Zonation program.



DEPTH (cm)	POLLEN TYPE
1.5-3.0	*Lotus* type
3.0-4.5	*Lysimachia* type, *Teucrium, Aster* type
9.0-10.5	*Fallopia (Polygonum) convolvulus* type
13.5-15.0	*Rhododendron*
15.0-16.5	*Crataegus* type
19.5-21.0	*Prunus* type
21.0-22.5	*Osmunda*
28.5-30.0	*Genista* type
30.0-31.5	Eupotamogeton
34.5-36.0	*Lycopodiella (Lycopodium) inundata*
37.7-39.0	Liliaceae type
39.0-40.5	*Polygonum amphibium, Mentha* type
40.5-42.0	*Polygala*
43.5-45.0	*Carduus*

Table 4.4 Pollen types found in BMP4 not included in the main pollen diagram.

lanceolata, Liguliflorae, Gramineae, *Pteridium* and *Polypodium*.

The results of these analyses are given in Figs. 4.23 and 4.24.

4.5.4 Local Pollen Assemblage Zone Descriptions:

Zone BMP4A. Depth 46.5 - 22.5cm

The upper boundary of this zone, between samples 16 and 15 is only found to be significant by the SPLITINF program. However the criteria used in deciding to place a zone boundary will be discussed later. SPLITLSQ assigns importance to the division between samples 18 and 17; however, this is simply due to the fluctuation in amounts of *Calluna* pollen between these two samples. The DECORANA plot shows the samples making up this zone forming a close cluster, associated with low axis 1 values.

This zone is dominated by high values of Ericaceous pollen. Shrub and herbaceous pollen types together with fern spores are also at their most numerous in this zone. *Calluna* is the most numerous pollen type, it fluctuates markedly between 25% T.P. and 62% T.P., but there is a tendency for it to increase up the zone.

Gramineae is the most important herbaceous pollen type , it varies between 5% T.P. and 18% T.P., averaging 11.5% T.P.. Other important herbaceous pollen types present include Liguliflorae, *Plantago lanceolata*, *Anemone*. *Corylus* accounts for practically all the shrub pollen in this zone. It falls through the zone, from

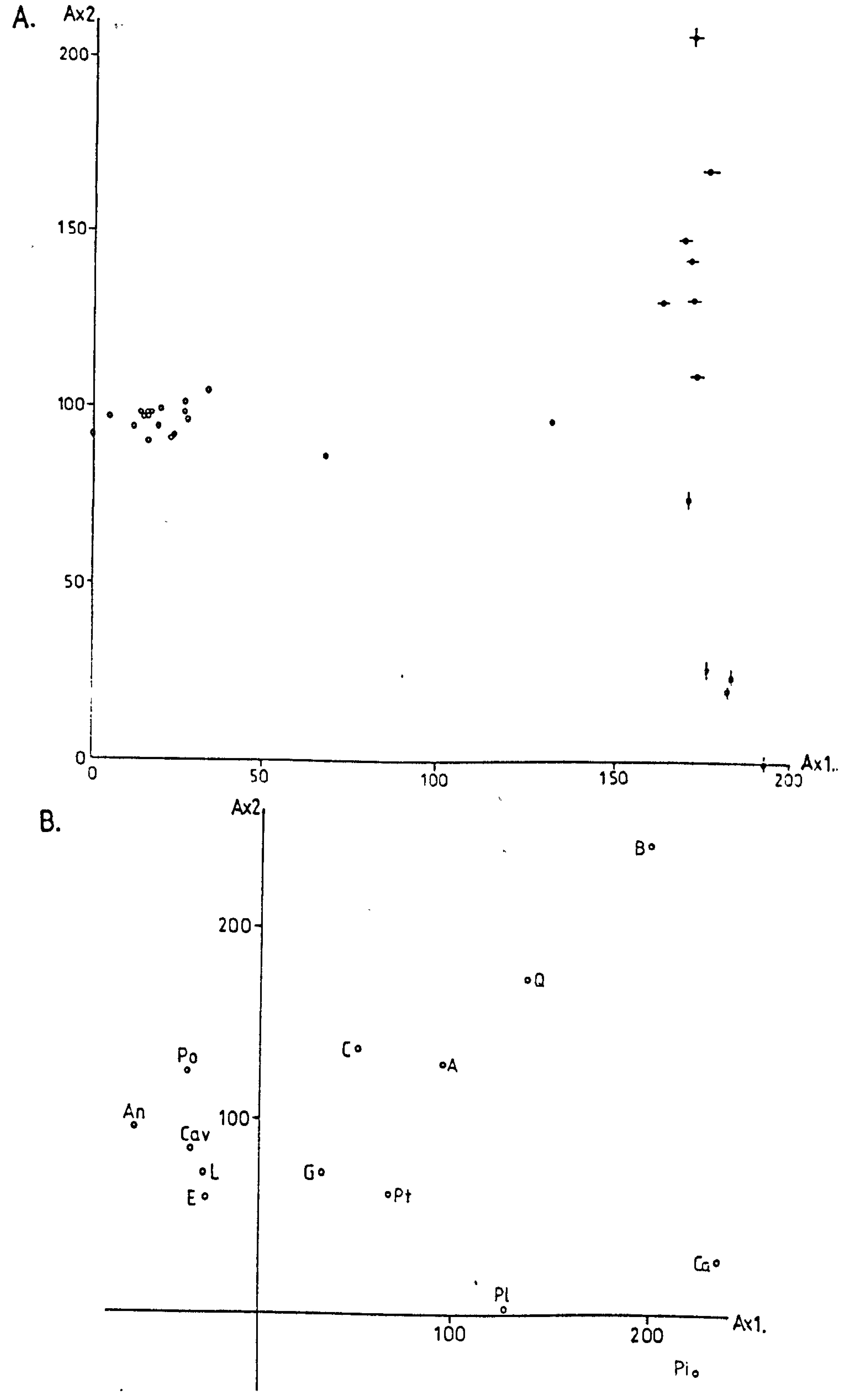


Fig. 4.23 BMP4-DECORANA A-Samples B-Species

(Key overleaf)

Fig. 4.23 (cont.)

Key.

A: Samples

o Assemblage zone BMP4A

● Assemblage zone BMP4B

ɸ Assemblage zone BMP4Ca

-o- Assemblage zone BMP4Cb

-ɸ- Assemblage zone BMP4Cc

B: Species

Pi - Pinus	E - Erica
B - Betula	An- Anemone
A - Alnus	Pl- Plantago lanceolata
Ca - Castanea	L - Liguliflorae
Q - Quercus	G - Gramineae
C - Corylus	Pt- Pteridium
Cav- Calluna	Po- Polypodium

values of upto 17% T.P. in the lower region of the zone to below 10% T.P.in the uppermost samples.

Pteridium is the most important fern, present in stable amounts, averaging 8% T.P.. *Polypodium* is relatively common in lower samples of the zone, reaching 2% T.P..

Alnus and *Quercus* are the most important arboreal pollen types. They are stable, averaging 7.5% and 5% T.P. respectively. Small amounts of *Pinus* and *Betula* are consistently present in this zone, but they never exceed values of 4% T.P.. *Fagus* appears to be more important in the upper portion of the zone but is present in very small quantities.

Zone BMP4B. Depth 22.5 - 18cm

The upper boundary of this zone, between samples 13 and 12 is shown to be significant by all the zonation programs. However, the split between samples 14 and 13 is shown to be the most important in the whole diagram. As might be expected the DECORANA plots for the members of this zone reflect their transitional nature; sample 15 falls within the BMP4A cluster, while the other samples show increases in axis 1 values, moving closer to the BMP4C grouping.

The pollen spectrum of this zone is characterised by an increase in the amounts of *Pinus* and *Betula*, combined with a decrease in the values of *Calluna*. The lower boundary is placed between samples 16 and 15, because it is in sample 15 the increase in *Pinus* and *Betula* can first be seen. *Pinus* and *Betula* both rise to around 30% T.P. by the top of the zone, while *Calluna* drops to 21% T.P.. The amounts of other pollen types present show little change or drop slightly; however the number of different herbaceous pollen types represented, does fall in this zone.

Zone BMP4C. Depth 18 - 0cm

This zone is characterised by high arboreal pollen values. The division of the zone into sub-zones is a reflection of the changes in the arboreal pollen spectrum within this zone. The upper boundary of sub-zone BMP4Ca, between samples 8 and 7 is found to by significant by all the zonation programs. But the upper boundary of sub-zone BMP4Cb is not found to be significant be either SPLITINF or SPLITLSQ. However the results of CONSLINK do show that sample 1 is not closely related to the samples of sub-zone BMP4Cb.

The DECORANA plot shows that all the samples of BMP4C are associated with high axis 1 values, but there is a great deal of variation in the axis 2 scores. BMP4Ca is seen to be associated with low axis 2 values, BMP4Cb with higher axis 2 values and BMP4Cc with the highest. The DECORANA plot also reveals that samples 8 and 7 show there is a gradual transition between sub-zones BNP4Ca and BMP4B rather than a sharp break. The descriptions of the pollen assemblages of these sub-zones are as follows.

Sub-zone BMP4Ca. Depth 18 - 10.5cm

This sub-zone can be characterised by an increase in the amounts of *Pinus*. They climb to a peak of 76% T.P., but then fall. The increase in *Pinus* is accompanied by a drop in *Betula*: it falls to a low of 2% T.P. but then increases by the end of the sub-zone. A dramatic drop is seen in *Calluna* pollen in this zone; its values are stable during this sub-zone and average 3% T.P.. Little change however is seen in the amounts of *Alnus* and *Corylus*, they average around 4% and 3% T.P. respectively. *Quercus* is seen to increase towards the top of the sub-zone reaching 15% T.P., while *Castanea* is first seen to be present in significant amounts. Little change is seen in Gramineae and *Pteridum*; they both show averages of around 4% T.P..

Sub-zone BMP4Cb. Depth 10.5 - 1.5cm

This sub-zone is characterised by high amounts of *Betula* and a decrease in *Pinus*. *Betula* is relatively stable except for a peak of 52% T.P., it averages 39% T.P. through the sub-zone. *Pinus* continues the decrease first observed in the previous sub-zone, falling to a low of 15% T.P., however it increases slightly after this point to around 20% T.P.. Amounts of *Alnus* and *Corylus* are higher than in the previous sub-zone; they average 7% and 5% T.P. respectively. *Quercus* values are also stable, averaging 13% T.P.. Gramineae too is stable through this sub-zone, but it has dropped in importance, averaging less than 3% T.P.. A slight increase in

Pteridium is seen towards the top of the zone, where it reaches 7% T.P.. *Calluna* drops further in importance. It is never present in amounts above 1% T.P..

Sub-zone BMP4Cc. Depth 1.5 - 0cm

This sub-zone is characterised by a dramatic increase in *Betula*, to a value of 66% T.P., and a drop in *Pinus* to less than 2% T.P.. *Quercus* achieves its highest value, 17% T.P., but as this sub-zone consists of only one sample, little meaningful change can be detected in the other taxa present.

4.5.5 ^{14}C analysis.

Two samples from this monolith were selected for ^{14}C analysis, they were:

1. SRR-3422 Made up of the mor humus from the depth of 19.5 - 21cm below the present surface, this sample gave a 'modern' date.
2. SRR-3421 Made up of the mor humus from the depth of 10 - 12cm below the present surface, this sample gave a 'modern' date.

4.5.6 Local Pollen Assemblage Zone Interpretation.

Zone BMP4A.

The fact that a soil monolith was analysed to produce this diagram has to be taken into account when interpreting the pollen assemblages obtained. In a mineral soil, such as is the case here, Dimbleby (1985) pointed out that the predominantly downward movement of water in the soil brings about the downward movement of pollen. However, this downward movement of pollen is very slow, as at any one time most of the soil's pollen content is immobile, bound up in the soil possibly in the form of a humic complex (Dimbleby 1962,1985). The pollen is only released when the soil-pollen aggregate breaks down.

In an acid soil, such as the buried podzol we are dealing with in this assemblage zone, in which there are no earthworms, Dimbleby (1985) stated that there is a characteristic distribution of pollen with depth. The bulk of the most recent pollen will be in the upper part of the profile, but some grains will have moved down the profile. Most of the ancient pollen is in the lower layers, with a remnant in the upper levels, while pollen of intermediate age will be spread through a wide range of depth and peak between the other two. Hence, no true stratification is seen in soil. At any one depth, pollen of various ages will be present. This will not apply to the mor humus overlying this soil (see later).

Other problems include that of differential decay of pollen grains (Havinga 1964). Dimbleby (1985) suggested that this tends to mean that in the upper levels of soils more taxa are represented, while in lower levels there will be higher percentages of fern spores and resistant grains than might other wise be expected.

It is also possible that there is a certain degree of downward movement of pollen along root channels.

The dominance of *Calluna*, the relative importance of herbaceous taxa and the low levels of arboreal pollen, show that a heathland system was formerly present on this site. The consistent presence of *Erica*, the importance of Gramineae and *Pteridium*, and the records of heathland indicators such as *Rumex acetosella* and *Genista* type all help to confirm this hypothesis. The record of *Lycopodiella inundatum* (formerly *Lycopodium inundatum*) suggests the heathland could have been rather wet, at least in part. The presence of this vegetation type in the past is also consistent with the podzolic profile of this mineral soil.

However, due to the nature of pollen distribution in mineral soils it is possible that an open heathland is not the only vegetation type represented by this assemblage. *Corylus* is more frequent in the lower portion of the zone and *Calluna* is slightly more frequent in the upper portion, which suggests that the *Corylus* pollen could be largely derived from an older assemblage. Although this would be consistent with the BMP3B assemblage which suggests the possible presence of a transitional period, soon after the clearing of the origional woodland, when a *Calluna/Corylus* scrub might have been present, it is most probable that the *Corylus* is derived from the area beyond the heath.

It is difficult to assess the regional importance of the arboreal species in this assemblage. The increase in importance of *Pinus* and *Fagus* in the upper portion of the zone, shows these species were becoming commoner regionally. In the case of *Fagus*, if its low pollen productivity and dispersal is taken into account, this increase could be quite large. The *Pinus* probably represents the first plantations of this tree in the area, although it is possible that some of this pollen could be derived from more recent vegetation by downward pollen movement in the humus. *Alnus* is the most numerous arboreal pollen type, probably a reflection of its role in the presumed nearby alder carr/pond-edge communities.

Liguliflorae is numerous as a result of two factors: firstly this pollen type includes many different taxa (it is possibly derived from pastoral, arable or possibly naturaly occurring communities). Secondly, it might be that this pollen type is more resistant to decay in soils than that of other types and is still more recognisable when partially degraded. The *Plantago lanceolata* is an indicator of pastoral agriculture in the region. It is possible that the records of *Potentilla* and *Rumex acetosella* pollen indicate a degree of grazing on the heath itself. The numerous records of *Anemone* pollen would appear to be anomalous to the assemblage as a whole as this species is normally associated with deciduous woodland. But it could represent a local, relict population on this site.

It is of note that the percentages of *Pteridium* spores are at their highest during this zone. Although this species was almost certainly part of the heathland community, the high values could be a reflection of the resistance to decay of fern spores. *Polypodium* is at its commonest at the bottom of the zone, which could indicate the presence of more heavily wooded conditions not otherwise represented in the assemblage.

Zone BMP4B.

The change in stratigraphy seen in this zone is important for purposes of interpretation. The change from mineral soil, to mor humus implies a change in the manner in which pollen is incorporated into the sediment. Such sediments consist of accumulating organic matter derived directly from the local vegetation (Dimbleby, 1985). Material accumulates on the mineral soil in a stratified manner and hence the problems in the interpretation of pollen assemblages from these sediments will be similar to those of peat (Moore and Webb, 1978; Dimbleby, 1985). However as humus shrinks and swells, there may be some downward movement of pollen down cracks. Also faunal elements may produce some mixing of the sediments. Although, as in mineral soils, there may be an element of differential pollen destruction, Aaby (1983) concluded that this was not an important source of error in pollen analysis in this type of material.

In this zone the transition from an open heathland to a closed woodland system can be seen. Fig. 4.20 gives an arboreal pollen diagram constructed using the Andersen correction factors that were applied to the assemblage zone BMP3C from the previous core. It must be noted, however, that they are not strictly applicable to this zone as the tree canopy can be seen to be incomplete but expanding. This implies a pollen catchment area larger than that for a closed woodland.

The invasion of *Betula* and *Pinus* onto the heath is seen, presumably in response to a drop in grazing pressure, allowing tree seedlings to become established. The similarity between the events in this assemblage and that of BMP3Cb suggests that they are contemporaneous. This view is supported by the sample from this zone, SRR-3422, which was ^{14}C dated. This sample gave a modern date and is consistent with the dates obtained from the BMP3 core. The establishment of the trees is accompanied by a decline in the values of *Calluna* and *Erica* pollen. As mentioned in the interpretation of BMP3Cb, this is almost cetainly due to the effects of shading by the invading trees.

The decline in herbaceous pollen seen, is presumably due to the developing arboreal canopy altering the pollen catchment and the shading out of the local ground flora.

Zone BMP4C.

Sub-zone BMP4Ca.

If the previous zone was equivalent to BMP3Cb, it can be seen that comparisons can also be made between this sub-zone and BMP3Cc. Again the sample ^{14}C dated from the top of this sub-zone, SRR-3421, as might be expected gives a modern date. The rise in arboreal pollen suggests that a closed tree canopy has now formed. This allows the

Andersen correction factors to be used with more confidence.

As in BMP3Cc the major feature of this zone is that *Pinus* has risen to dominate the immediate area, overtopping the *Betula*. The corrected arboreal pollen diagram suggests it accounted for around 70% of the canopy. However one feature not seen in BMP3Cc is the rise in the levels of *Quercus* towards the top of the sub-zone. This is almost certainly due to the first flowering of the oaks, beneath which this core was taken. It is possible that these trees were among the primary invaders of the heath, as it commonly acts as a pioneer tree Rackham (1980). The subsequent delay seen in the rise the *Quercus* pollen curve is almost certainly a reflection of that fact it matures slowly and its onset of flowering can be late (Wareing, 1959). The values of *Castanea* pollen are greater than that seen in BMP3Cc implying a closer proximity to any local stands of this tree.

The low amounts of *Corylus* and that fact that it is unlikely to invade the heath, suggests that its pollen is derived from outside the local wooded area. This hypothesis is supported by the fact that the amounts of *Corylus* pollen in this sub-zone are lower than those seen in BMP4Cc (which presumably reflects the present-day vegetation), and *Corylus* is not important at the site today.

Pteridium is likely to have dominated the ground flora of the site since the formation of the secondary woodland canopy. It is present in roughly similar amounts through the whole of zone BMP4C, and dominates the ground flora around the sampling site today. The low numbers of *Calluna* suggest that it may still be present as a minor component of the ground flora.

The record of *Rhododendron* pollen in this sub-zone is noteworthy, assuming that this record is not due to a more recent grain moving down the profile via one of the processes outlined earlier, it would suggest that this species, which is becoming increasingly important at the site, first became established early in the development of this secondary woodland. This could help to establish the age of this zone since *Rhododendron* was only introduced into this country in the 19th century, so the woodland cannot have developed before this time.

Sub-zone BMP4Cb.

This sub-zone can be seen to be equivalent to sub-zone BMP3Cd. However, the drop in *Pinus* and increase in *Betula* is more marked here than in the equivalent sub-zone. This favours the argument that there was a partial clearance of *Pinus*, allowing *Betula* to become established in the gaps created. The frequent records of *Ilex* pollen, in this and the latter stages of the previous subzone, are of note as increases in the numbers of this tree are often associated with a decline in grazing pressure (Rackham, 1980). This suggests it may have been present on the heath prior to the formation of the secondary woodland.

The slight increase in *Pteridium* and the fall in *Calluna* indicate that the ground flora is now even more uniform than indicated in the previous zone. Although Gramineae and *Plantago lanceola* are the most numerous pollen types throughout zone BMP4C, these grains are almost certainly derived from areas of pastoral activity outside the woodland on the New Piece area. A possible indicator of nearby arable agriculture is *Fallopia convolvulus* (formerly *Polygonum convolvulus*), often a weed of arable land or gardens.

Sub-zone BMP4C.

In this sub-zone the clearance of most of the *Pinus* remaining in the local area is seen. This has led to the pattern of vegetation seen around the sampling site today becoming established. *Betula* dominates the area, with the relatively high amounts of *Quercus* reflecting the stand of trees next to the sampling site. Although *Pteridium* dominates the ground flora today, its lowest value in the diagram is found in this sub-zone.

4.6 Burton Mill Pond Core 5 (BMP5)- Peat Core No.2.

This core was taken from the Black Hole region of Welsh's Common which lies to the East of the Mill Pond (see Fig. 4.2.).

4.6.1 Stratigraphy.

38-52cm Poorly humified peat.

52-57cm Dark unconsolidated peat.

57-63cm Water gap .

63-68cm Unconsolidated peat.

68-83cm Dark compacted peat with rootlets.

83-88cm Black organic sand.

4.6.2 Pollen Stratigraphy.

This core was sub-sampled every 4cm. A minimum of 500 pollen grains and spores were counted, excluding Cyperaceae, *Potamogeton* and *Sphagnum*. Also, due to their high values in some parts of the diagram and predominantly bog surface character, Cyperaceae, *Potamogeton* and *Sphagnum* were excluded from the pollen sum (T.P.), but are expressed as a percentage of this pollen sum. The summary pollen diagram is given in Fig. 4.25 and the main pollen diagram in Fig. 4.26. Pollen types found in BMP5 not included in the main pollen diagram are shown in Table 4.5.

4.6.3 Numerical Analysis.

The following pollen types were used in the computer

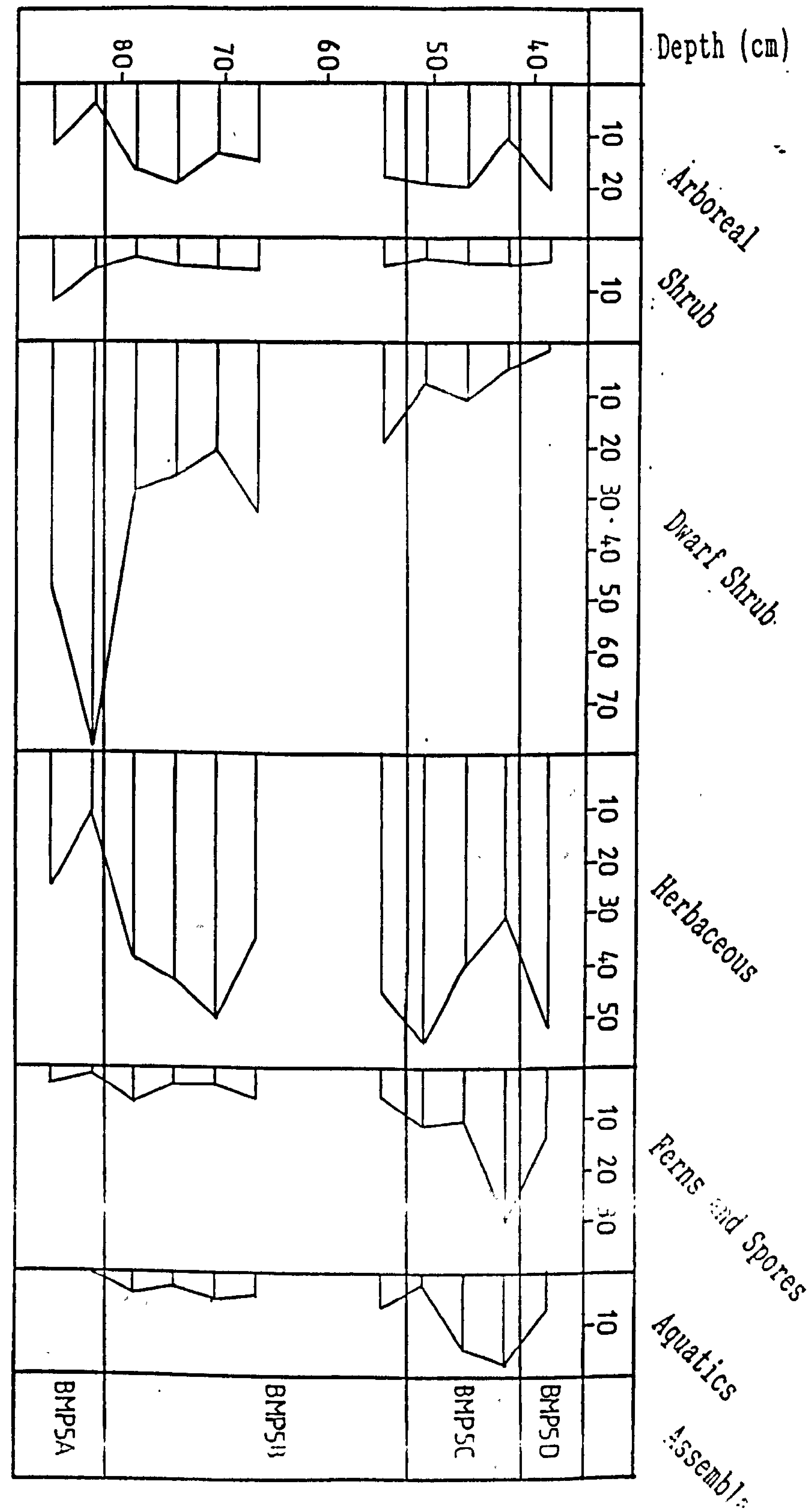


Fig. 4.25 - BMP5 Summary Pollen Diagram.

(Values expressed as percentage of sum of total pollen and spores.)

Fig. 4.26 BMP5 - Main Pollen Diagram
All values expressed as percentages of the ammended pollen sum.(+ represents values <1%)

Fig. 4.26 Cont.

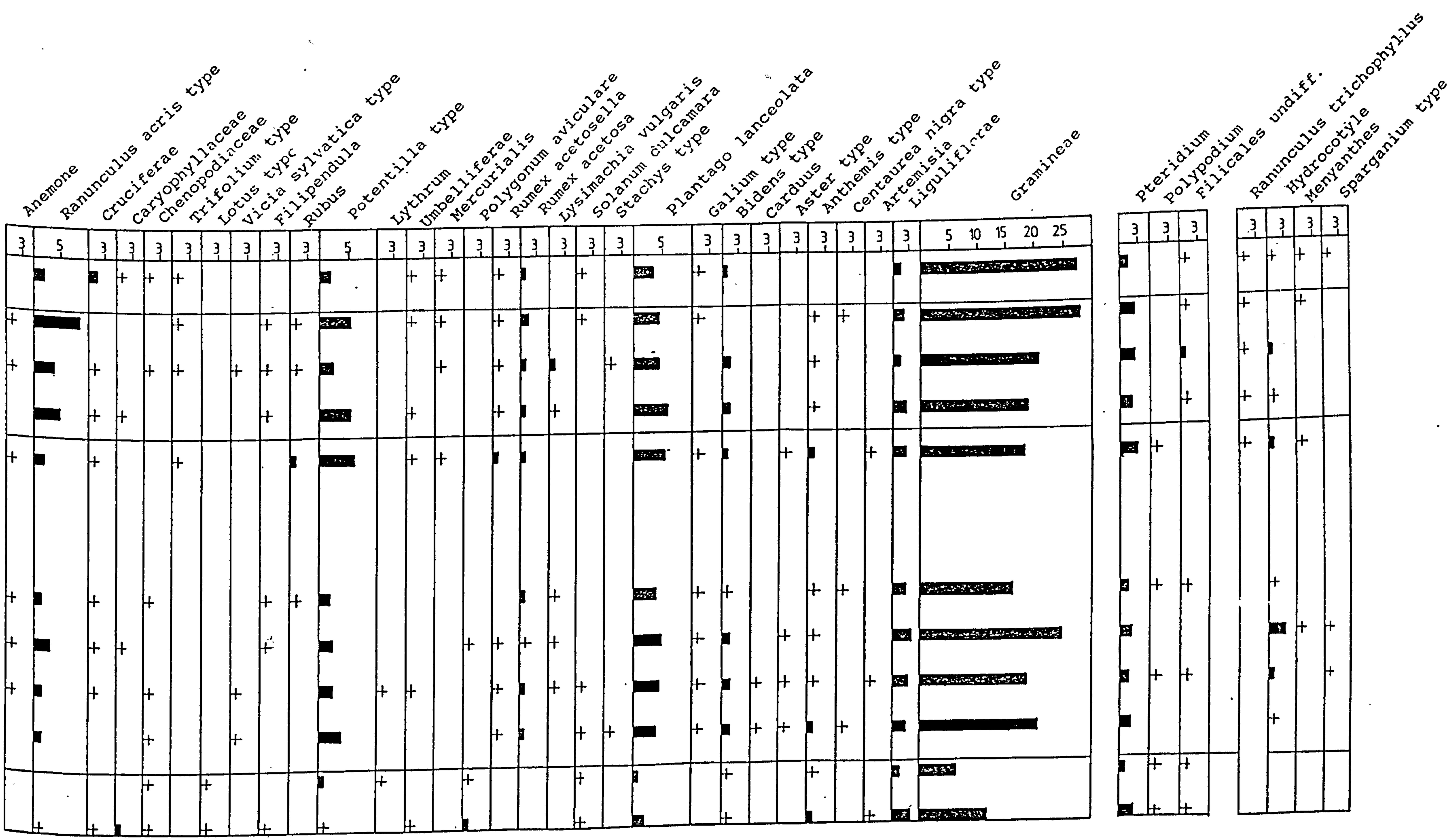

Anemone
Ranunculus acris type
Cruciferae
Caryophyllaceae
Chenopodiaceae
Trifolium type
Lotus type
Vicia sylvatica type
Filipendula
Rubus
Potentilla type
Lythrum
Umbelliferae
Mercurialis
Polygonum aviculare
Rumex acetosella
Rumex acetosa
Lysimachia vulgaris
Solanum dulcamara
Stachys type
Plantago lanceolata
Galium type
Bidens type
Carduus
Aster type
Anthemis type
Centaurea nigra type
Artemisia
Liguliflorae
Gramineae
Pteridium
Polypodium
Filicales undiff.
Ranunculus trichophyllus
Hydrocotyle
Menyanthes
Sparganium type
5 10 15 20 25

Fig. 4.26 Cont.

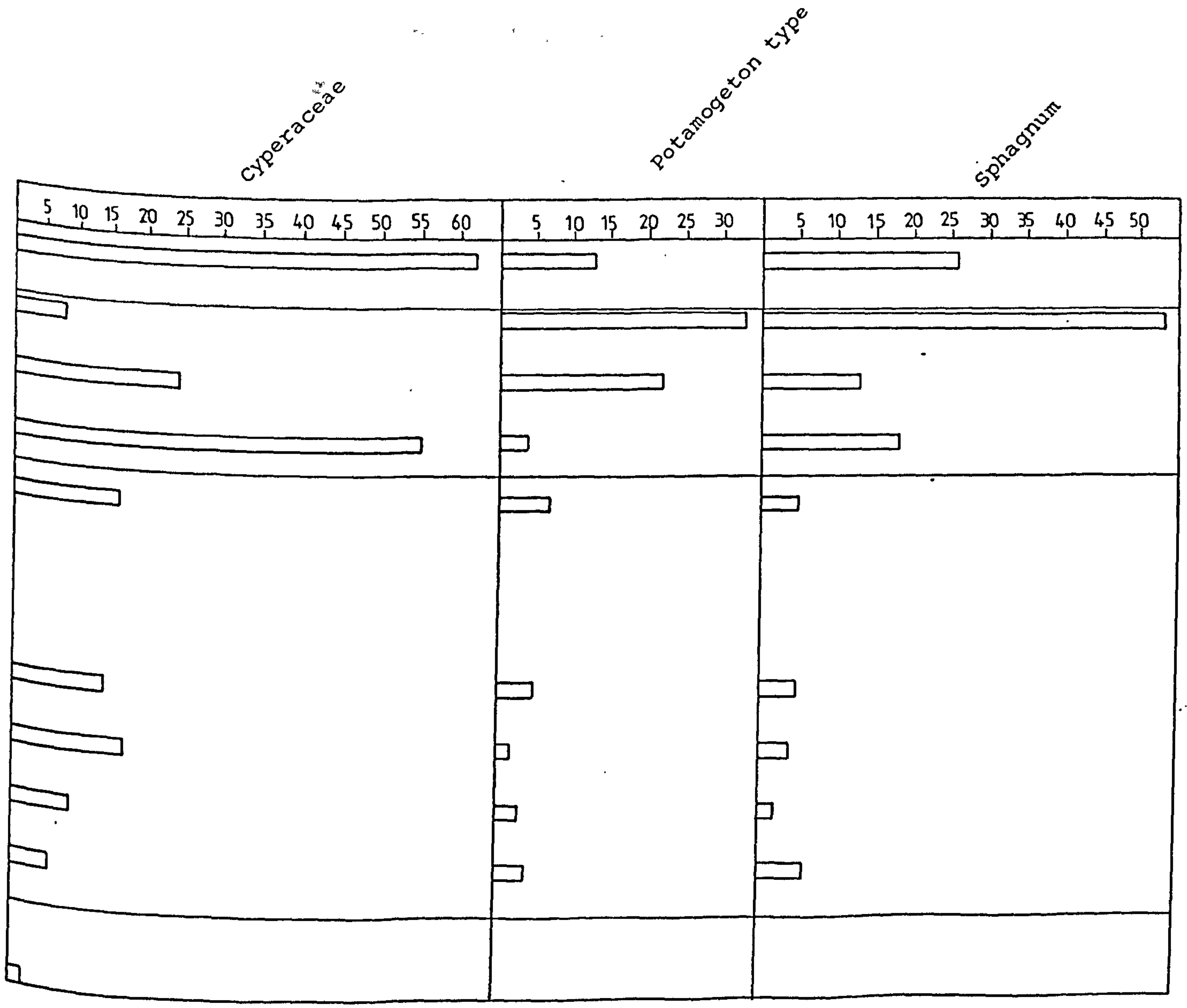
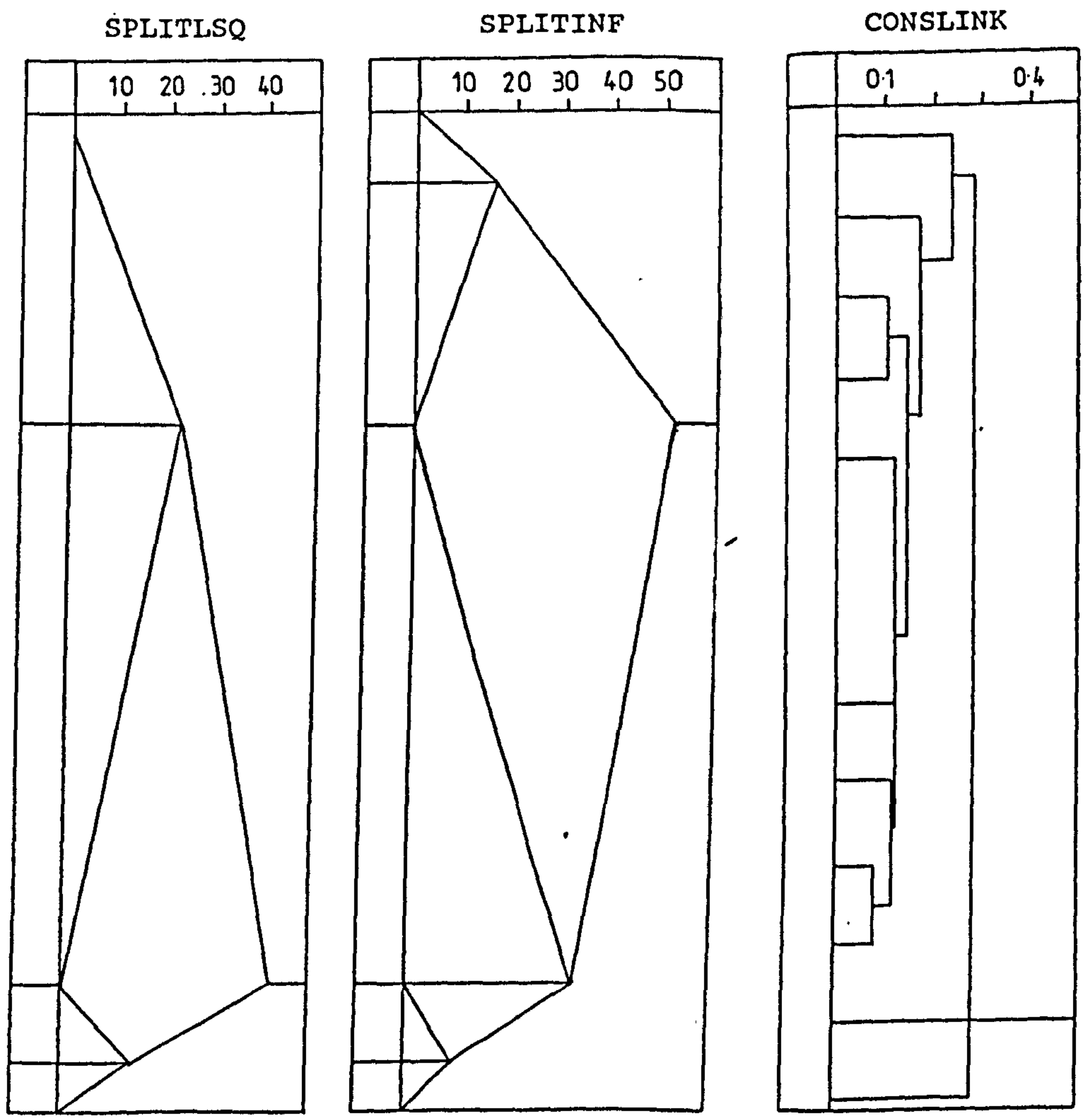


Fig. 4.28 BMP5 Results of the Zonation program.



<u>DEPTH</u>	<u>POLLEN TYPE</u>
38-39	*Picea, Onobrychis* type
42-43	*Genista* type, *Fallopia convolvulus* type
46-47	*Juglans, Fagopyrum* type, *Typha latifolia*
50-51	*Genista* type, *Ononis* type, *Drosera rotundifolia, Valeriana officinalis*
54-55	*Geum*
66-67	*Jasione*
70-71	*Nymphaea*
74-75	*Sanguisorba minor, Valeriana dioica*
78-79	*Spergula arvensis, Urtica, Cannabis* type, *Teucrium*

<u>Table 4.5</u> Pollen types found in BMP5 not included in the main pollen diagram.

analysis: *Pinus*, *Betula*, *Alnus*, *Fagus*, *Quercus*, *Corylus*, *Salix*, *Calluna vulgaris*, *Erica*, *Ranunculus acris* type, *Potentilla*, Liguliflorae, Gramineae and *Pteridium*.

The results of these analyses are given in Figs. 4.27 and 4.28.

4.6.4 Local Pollen Assemblage Zones Descriptions.

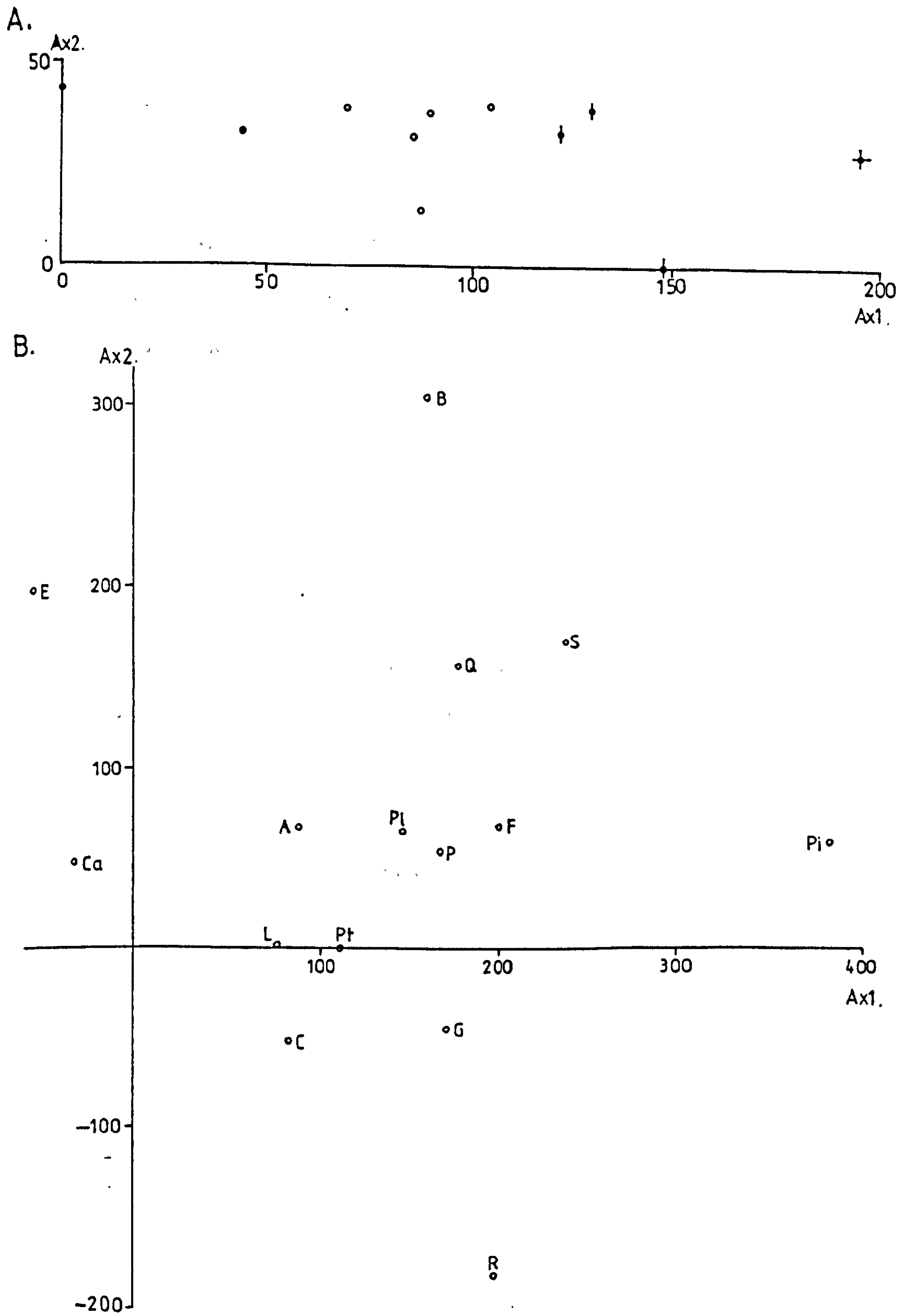
Zone BMP5A. Depth 87-81.5cm

Mathematically the upper boundary of this zone, between samples 9 and 10 is regarded as significant by all the zonation programs. However it can be seen that all three programs also find a significant split between samples 10 and 11. This division can be explained by the very high amount of *Calluna vulgaris* pollen seen in sample 10. The DECORANA plot for this core assignes the samples of this zone the lowest axis 1 values; there is no overlap with members of any other zone.

The zone is dominated by high numbers of *Calluna* pollen, values of 47% and 73% T.P. being found. These high proportions of *Calluna* pollen obviously affect the percentages of other pollen types seen, the other important taxa present being *Corylus* and Gramineae, which both have average values of 9% T.P., and *Quercus* and *Alnus* which both average 3% T.P..

Zone BMP5B. Depth 81.5-52.5cm

The split between sample numbers 5 and 4 is selected as significant by SPLITLSQ and SPLITINF, but is regarded



<u>Fig. 4.27 BMP5-DECORANA A-Samples B-Species.</u>

(Key overleaf)

Fig. 4.27 (cont.)

Key.

A: Samples.

● Assemblage zone BMP5A

o Assemblage zone BMP5B

Assemblage zone BMP5C

Assemblage zone BMP5D

B: Species.

Pi- Pinus	Ca- Calluna vulgaris
B - Betula	E - Erica
A - Alnus	R - Ranunculus acris
F - Fagus	P - Potentilla
Q - Quercus	L - Liguliflorae
C - Corylus	G - Gramineae
S - Salix	Pt- Pteridium

as of less importance by CONSLINK. DECORANA shows these samples forming a distinct group with higher axis 1 values. It should be noted that the axis 2 scores of all the samples show relatively little variation.

Calluna is still the most important pollen type in this assemblage, fluctuating between 23% and 39% T.P., but overall averaging 29% T.P.. The fall in the values of *Calluna* is accompanied by an increase in the numbers of most other important pollen types, all of which remain relatively stable throughout this zone. Gramineae and *Quercus* increase most markedly to 20% and 11% T.P. respectively. *Betula*, *Alnus* and *Fagus* all increase, averaging 1.5%, 4% and 2.5% respectively. *Corylus*, however, is less important in this zone. It falls to an average value of 6%.

An increase is seen in the numbers of herbaceous pollen and also the number of taxa represented, the most important being *Ranunculus acris* type, *Potentilla* type and *Plantago lanceolata*. Increases are also seen in the taxa not included in the main pollen sum. Cyperaceae, *Potamogeton* and *Sphagnum* are all present in significant quantities.

Zone BMP5C. Depth 52.5-41.5cm

The upper boundary of this zone, between samples 2 and 1 denoted as significant by SPLITINF and CONSLINK. The samples making up this zone form a discrete grouping on the DECORANA plot, with higher axis 1 values than the samples of the previous zone.

The amounts of *Calluna* are again lower than in the previous zone and are stable within this zone averaging 13% T.P.. *Quercus* increases to a maximum of 20% T.P. in sample 4 but falls to 12% T.P. by the end of the zone. Amounts of *Fagus* are higher, but are stable within the zone, averaging 5.5% T.P., while Gramineae increase through the zone to reach 28% T.P. in sample 2. Numbers of other herbaceous pollen types remain similar to the previous zone, except for an increase in *Ranunculus acris* type. A dramatic increase in the amount of Cyperaceae present is seen in sample 4, however it falls steeply in the rest of the zone. Amounts of *Potamogeton* and *Sphagnum* are both seen to increase during this zone.

Zone BMP5D. Depth 41.5-37cm

This sample continues the trend seen in the previous zone on the DECORANA plot, having a significantly higher axis 1 score.

This zone consists of a single sample characterised by the high value of *Pinus* (17% T.P.). *Calluna* has dropped to its lowest value in the whole diagram achieving only 3.6% T.P.. Apart fom the increase in *Pinus* the spectrum of arboreal and shrub pollen types is broadly similar to the previous zone. However with the exception of Gramineae, (which accounts for 28% T.P.)and Cyperaceae which is present in large ammounts, the numbers of herbaceous pollen types are generally lower. *Potamogeton* and *Sphagnum* have fallen from the previous zone but are still significant.

4.6.5 ^{14}C Analysis.

One sample from this core was selected for dating. Made up of compacted and peaty sand from the depth of 80-88cm, this sample SRR-3423 was dated at 940 ± 70 years B.P..

4.6.6 Local Pollen Assemblage Zone Interpretation.

Zone BMP5A.

The stratigraphy making up this assemblage zone is similar to that seen in the bottom most section of core BMP1, in that it appears to be the top portion of a heathland soil (namely the mor humus and A horizons). When the high amounts of *Calluna* pollen present are compared to the surface transect data of Evans and Moore (1985) it is clear that the percentage coverage of *Calluna* in the immediate vicinity of the sampling site could be as high as 80%. Other than Gramineae and *Erica* there are few other pollen types, with the possible exception of *Potentilla*, that are strongly associated with heathland in the assemblage, but this could be a reflection of dense *Calluna/Erica* cover in the immediate area of the sampling site.

An indication of the openness of the site is given by the low numbers of arboreal and shrub pollen. If one compares the percentages of these pollen types with the work of Tinsley and Smith (1974), it is clear that they are too low to have derived from trees growing in the immediate area of the sampling site. The arboreal spectrum does, however, suggest that regionally the woodland consists largely of *Quercus*, with *Fagus* and *Betula* relatively common. *Corylus* is present, most likely either in scrub vegetation or as coppiced underwood.

The relative richness of the herbaceous flora is again a reflection the open canopy of the site. The *Plantago lanceolata* indicates the possibilty of pastoral agricultural practices in the area, while the relatively frequent records of *Polygonum aviculare* are of interest as it is possible that this indicates the presence of arable land in the vicinity of the sampling site.

The ^{14}C date associated with this zone suggests that this soil could predate the original building of the mill pond, by anything up to three centuries.

Zone BMP5B.

Apparently the start of this assemblage zone coincides with the start of peat growth at the site. The increased importance of *Potamogeton*, *Sphagnum*, *Hydroctotyle* and *Menyanthes* (all of which require wet conditions for growth, and whose pollen is not likely to be transported far), together with the rise in Cyperaceae pollen would suggest that the water table has risen at the start of this zone. It is probable that it is this occurrence that has initiated the peat growth. When the date suggested by ^{14}C analysis of the peat previous zone (940 ±70 years B.P.) is compared with the date from the heathland soil directly underlying the lacustrine sediments in the Mill Pond core BMP1 (SRR-3411), of 630 ± 65 years B.P., it at first seems unlikely that it was the building of the mill pond that caused this change in hydrology. However when one considers the amount of the two soils sampled, and that they could contain material of a wide range of age, and then take in to account the margins of error inherent in ^{14}C dating, the possibility that it was the building of the mill pond that caused the change in hydrology can not be completely discounted. The Black Hole region of the Nature Reserve from where this core was taken from is rather low lying, and immediately adjacent to the Mill Pond, and today has a consistantly high water table. It can therefore be seen that it would be strongly influenced by changes in the level of the Mill Pond in the past.

This hydrological change could be responsible for other differences in the local vegetation. The fall in the values of *Calluna*, together with the increase in grasses and herbs suggests that a grass/heath mosaic, rather than uniform heathland, is now present. However, it is possible that the fall in *Calluna* pollen could be due to very local changes in the *Calluna* cover (Evans and Moore, 1985). The records of *Erica, Rumex acetosella* and *Campanula* support the probable heathland nature of the site's vegetation. The increased numbers of *Potentilla* are more difficult to interpret as, because of the change in hydrology, it is possible that either *P.palustris* or *P.erecta* could be growing locally. The increase in

Plantago lanceolata and the records of *Rumex acetosa* could reflect an increase in the importance of pastoralism, while the record of *Spergula arvensis* pollen gives a strong suggestion of local arable agricultural practices. *Ranunculus acris* type pollen also increases in importance, but this again is probably in response to the change in hydrology. It is possible that a species represented in this pollen type that thrives in wet conditions such as *R.flammula* could account for the increase.

The increase in arboreal taxa may just be an artefact of the drop in the importance of *Calluna* in the assemblage. However, their values still suggest a regional rather than local source. A possible exception however, is *Fagus*. This species shows the highest increase, and when its low representation in pollen diagrams is taken into account, it would seen possible that it is now more important than *Quercus*.

The water gap seen in the sediments making up this assemblage zone is difficult to explain. There are no major differences in the pollen assemblage either side of the water gap suggesting that no major change in vegetation accompanied this event. It is possible that this gap could have been created by a further alteration in the local water table, such as that caused by the extension of the mill pond, but there is little evidence to support this theory.

Zone BMP5C.

There has initially been an increase in the numbers of Cyperaceae, then *Potamogeton* and *Sphagnum*, which suggests that the conditions recorded in this zone are possibly wetter than previously. The further fall in *Calluna* suggests that it may well be reacting to the wetter conditions, becoming confined to slightly drier areas such as the top of hummocks. The possible change in the local hydrology is consistent with the theory that the mill pond was extended towards the end of the previous zone.

Although higher values of arboreal pollen are found in this zone, they are still relatively low, suggesting that the general area around the sampling site is still open.

Zone BMP5D.

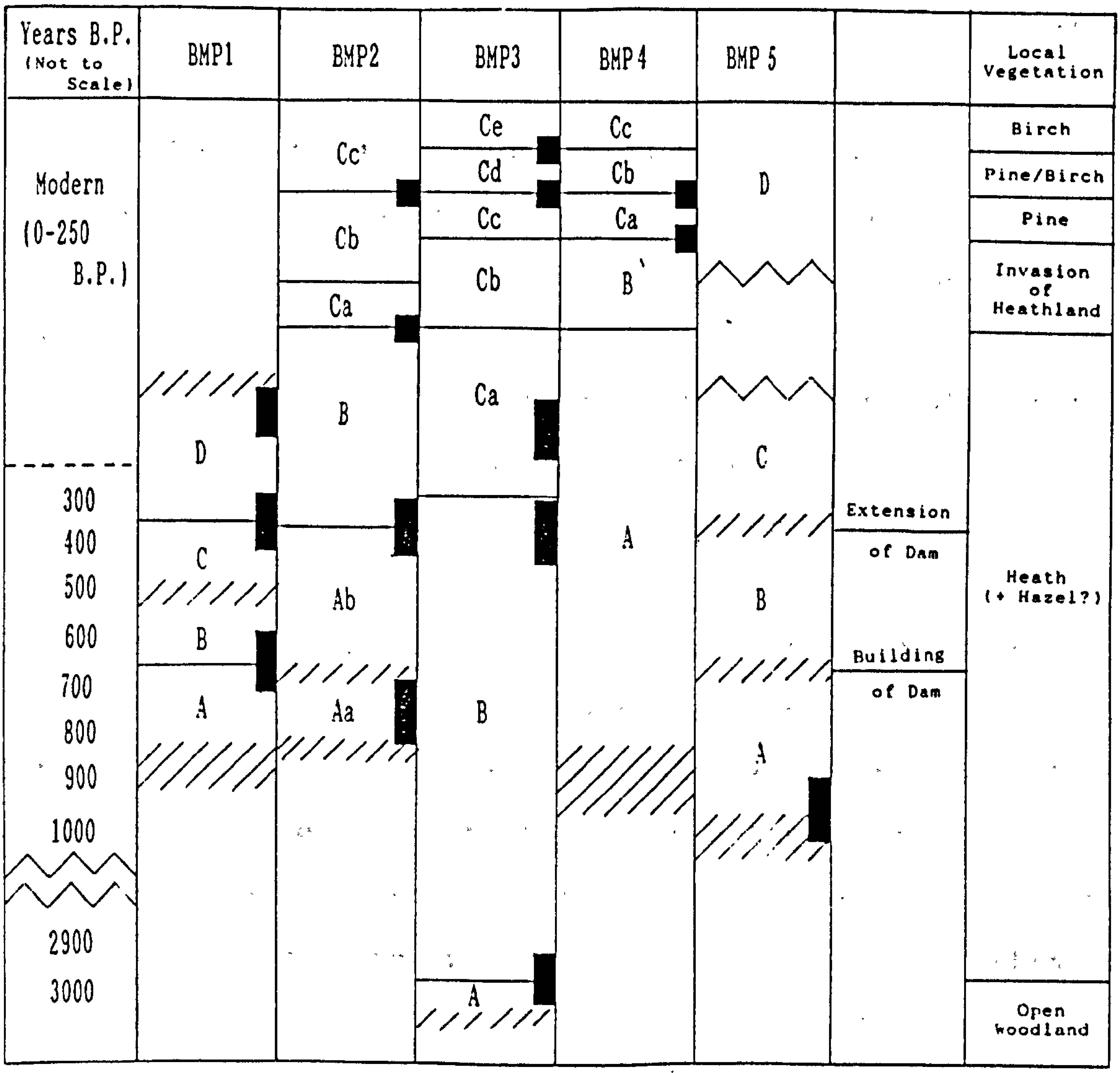
The disturbed appearance of the surface of this site and the high amount of *Pinus* pollen suggest that the site has been cut, and this assemblage represents the material that has accumulated since. This recent increase in *Pinus* is consistent with the results from BMP2, BMP3 and BMP4. The low amount of *Calluna* is of note because at the site today this species is still important locally. Although Cyperaceae is at its most numerous in this zone, the lower numbers of *Potamogeton* and *Sphagnum* suggest that the site could be drier than it was previously.

4.7 Core Correlation.

To aid understanding the correlation between all the cores studied from this site, Fig. 4.29 gives a diagramatic account of how the cores, and the local pollen assemblage zones within them, relate to each other over time. Also shown are the results of the radiocarbon analyses from all the cores, and a brief description of the contemporary local vegetation.

It can be seen that the earliest information from this site is provided by the valley mire peat core (BMP3). The peats from the bottom of this core gave a ^{14}C analysis date of 2910 ± 65 years B.P.. This suggests it could cover the mid to late Bronze Age. The earliest zone from this core (BMP3A), suggests that the area was largely covered by open woodland at this time, rich in *Corylus*, *Quercus* and *Tilia*, but also containing species such as *Calluna* and *Betula*.

The clearance episode that marks the boundary between BMP3A and BMP3B also falls within the peat sample ^{14}C dated mentioned above (SRR-3420). If one takes the depth of the peat represented by this sample and the timespan it is therefore likely to cover, it would seem best to consider this clearance as dating from the latter parts of the Bronze Age. The second local pollen assemblage zone from this valley mire core (BMP3B) apparently covers a longer time period than any other from any core from this site. The sample ^{14}C analysed from the upper portion of this assemblage zone gave a



Key.

■ - position of ^{14}C dated samples.

Fig. 4.29 Correlation of cores BMP1-5 with relation to time and local vegetation.

date of 340± 65 years B.P.. This suggests that, in all, this assemblage zone could cover a period of well over 2,000 years. The vegetation represented by this assemblage zone appears to be dominated by heathland, but with evidence of encroachment by scrub/woodland during the middle portion of the zone.

It is within the time period covered by BMP3B that the initial stages of all the other cores studied can be placed, either through ^{14}C dating or by comparison of pollen assemblages. The bottom sediments of the two cores from the mill pond (BMP1 and BMP2) and from the second peat core (BMP5) give ^{14}C dates of 630±65 years, 730 ± 70 years, and 940±70 years respectively, all of which fall in the period covered by BMP3B. Evidence for the presence of heathland is seen in all of these dated cores, so it is easily possible to place the beginning of the soil/mor humus core (BMP4) within this period. The first, undated, assemblage zone from this core (BMP4A) clearly represents a heathland pollen assemblage.

Evidence from BMP2, BMP3, and BMP4, backed up with ^{14}C analyses, all show that the heathland was present on the site until relatively recently. Unfortunately, the modern results given by these ^{14}C analyses are unable to suggest precise dates for when the heathland was lost.

Of course heathland is not the only vegetation type represented during this period, however, this will be discussed later as this section is mainly concerned with tying the cores together within a temporal framework. After the formation of the heath, the most important event in the history of the site is the building of the Mill Pond.

The fact that BMP1 shows a heathland soil sealed beneath lacustrine sediments shows that the pond was built simply by damming the stream running along the valley bottom and flooding the heath directly. The sample from the assemblage zone BMP1A which was ^{14}C dated at 630 ± 65 years B.P., shows that it it is unlikely that the pond was built before 1255 A.D., while it is possible that it dates from some time after 1385 A.D.. The start of the second Mill Pond core (BMP2) provides a ^{14}C date of 730 ± 70 years B.P., this is apparently earlier than the building of the Mill Pond. However the pollen from this assemblage gives little evidence of open water, suggesting that this site was occupied by alder carr. The ^{14}C date obtained from the soil found beneath the peat of the second peat core (BMP5) of 940 ± 70 years B.P., is consistent with the hypothesis that the peat growth at this site was initated at the time the Mill Pond was built.

Comparison of assemblage zones BMP1B and BMP1C with BMP2Ab is of interest here as the evidence from ^{14}C dating suggests that they represent the same period of time. The start of this period is the building of the Mill Pond while the end of BMP1C and BMP2A are dated as 320 ± 65 and 330 ± 65 years B.P. respectively. The first thing that is apparent is the difference in the sedimentation rate seen between the two cores, with BMP1 showing by far the fastest rate.

As discussed in previous sections, at the end of the period covered by BMP1C and BMP2B (1620-30 A.D. ± 65 years), evidence points to the fact that the mill pond was extended. It is of note that the ^{14}C date from the valley mire peat core (BMP3), close to the boundary between assemblage zones BMP3B and BMP3C, where a change in stratigraphy is also seen, is 340 ± 65 years B.P.. The similarity between this date and the date the Mill Pond was enlarged, suggests that this event could also be related to the extension of the dam. It is also possible that this event could mark the boundary between assemblage zones BMP5B and BMP5C in the second peat core.

The correlation of the more recent information from the five cores is much less reliant on information from ^{14}C dating. This is simply because the results from the radiocarbon analysis of the upper portions of the diagrams all yielded 'modern' dates from within the last 250 years. The possible error range of these results preclude accurate comparison between them. Therefore correlation between the latter parts of the pollen diagrams rely more heavily on evidence from the pollen itself.

The end point of the first Mill Pond core (BMP1) can be regarded as falling within the period covered by BMP2B and BMP3Ca (see Fig. 4.29). The evidence for this is from the absence of high levels of *Pinus* pollen form BMP1, as it is the expansion of *Pinus* that marks the start of assemblage zones BMP2C and BMP3Cb. Unfortunately it is impossible to give an exact date for this.

The loss of heathland from the New Piece area of the site (see Fig. 4.2) is clearly seen in the valley mire (BMP3) and soil/mor humus (BMP4) diagrams, where it marks the start of BMP3Cb and BMP4B. It is also seen in the second Mill Pond core (BMP2), although this assemblage contains a greater proportion of regionally derived pollen, where it marks the start of BMP2C. Even though these assemblages are derived from different sediment types, they show a consistent picture when compared with each other.

Although the similarities between BMP3 and BMP4 have been mentioned earlier it is possible to compare the data from these two cores using DECORANA, the results of which are shown in Fig. 4.30. From this diagram it can be seen that these two cores resemble each other most closely in the heathland phase, seen in BMP3B and BMP4A, and the *Pinus* dominated woodland seen in BMP3Cc and BMP4Ca. The differences between the two cores seen in the DECORANA plot highlight 1) how differences in sediment type can affect how the local vegetation is represented, and 2) how very local differences in vegetation can affect pollen assemblages derived from two nearby sites with small catchment areas.

The compact nature of the BMP4A samples on the DECORANA plot compared with the more diffuse BMP3B cluster can be interpreted as showing the differences in the sediment types the two assemblages were derived from. The relative uniformity of the BMP4A suggests a degree of mixing of the sediments with the accompanying loss of

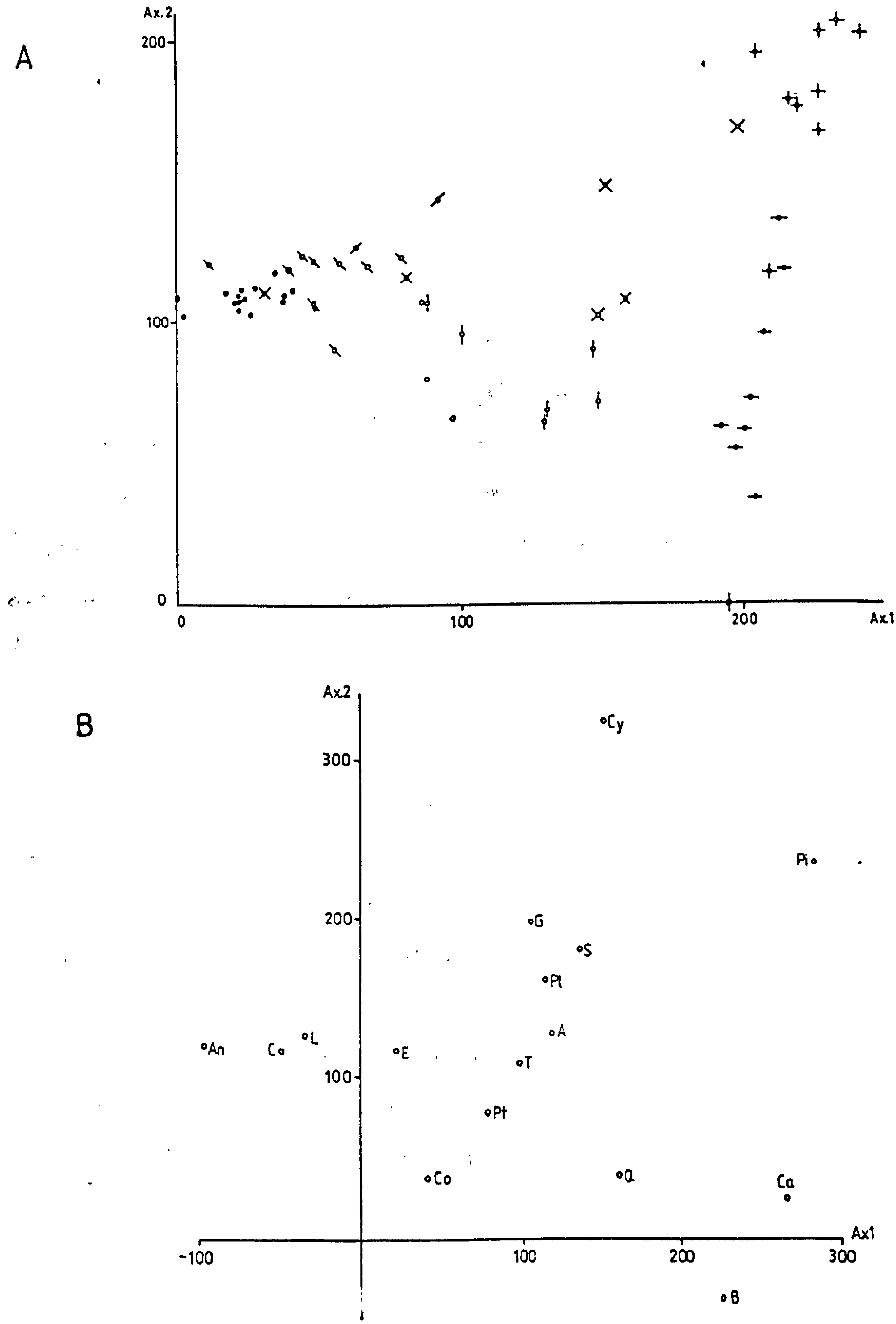


Fig4.30 DECORANA comparison of cores BMP3 and BMP4:
A - Sample scores, B - Species scores.

(Key overleaf.)

Fig4.30 cont.

Key.

Samples.

Assemblage zone BMP3A.	Assemblage zone BMP3B.
Assemblage zone BMP3B.	Assemblage zone BMP4B.
Assemblage zone BMP3Ca.	Assemblage zone BMP4Ca.
Assemblage zone BMP3Cb.	Assemblage zone BMP4Cb.
Assemblage zone BMP3Cc.	Assemblage zone BMP4Cc.
Assemblage zone BMP3Cd.	
Assemblage zone BMP3Ce.	

Species.

Pi- Pinus.	C - Calluna.
T - Tilia.	E - Erica.
B - Betula.	An- Anemone
A - Alnus.	Pl- Plantago lanceolata.
Q - Quercus.	L - Liguliflorae.
Ca- Castanea.	Cy- Cyperaceae.
Co- Corylus.	G - Gramineae.
S - Salix.	Pt- Pteridium.

temporal definition, while the loose nature of the BMP3B assemblage reflects the stratified nature of the peat sediment and the fact it is able to show the changes seen during the time period represented.

The second point can be seen by comparing BMP3Cd with BMP4Cb, and BMP3Ce with BMP4Cc (see Fig. 4.29). BMP3Cd and BMP4Cb are both assemblages that represent a local woodland rich in *Pinus* and *Betula* with some *Quercus*, but BMP4Cb appears to be from an area richer in *Betula* and the *Quercus*. The higher amounts of *Quercus* pollen present are almost certainly derived from the oaks that are growing still at the sampling site today. The two assemblages, BMP3Ce and BMP4Cc, both represent the vegetation seen at the site today, but they highlight very local differences. The fact that BMP3Ce was taken from the small open valley bog while BMP4Cc was taken from under a partially closed canopy, clearly explains the different positions of these two zones on the DECORANA plot. On the DECORANA plot the uppermost sample of BMP3Ce falls close to samples from BMP3A and BMP3B. This adds some evidence to support the theories that BMP3A represents a relatively open woodland (although it must be remembered that the DECORANA plot does not take into account the fact that species such as *Tilia* will be under-represtented), and that the BMP3B assemblage suggests that the heathland was encroached upon by more wooded conditions during its history.

When the sequence of events involved in the loss of the heathland is looked at in the second Mill Pond core

(BMP2), certain differences are seen that could place the events in a more regional context. The BMP3Ca assemblage shows high numbers of *Pinus* but also relatively high amounts of *Calluna*. As previously mentioned this suggests that the heathland has not been lost at this point and that the *Pinus* represents the planting of the tree elsewhere in the catchment. It is possible that it was from such trees in the region that the heathland was colonised. If this is the case, it is possibly at the start of BMP2Cb that the colonisation of the New Piece it started. However, it is of note that the brief peak in *Betula* apparent in both BMP3 and BMP4 at this point is not seen. This is likely to be a reflection of the relatively local nature of this event and the fact that the *Pinus* representation is improved as a result of higher pollen productivity and better dispersal. The increase in *Betula* pollen seen at at the start of BMP3Cd and BMP4Cb can be seen at the start of BMP2Cc, however when *Betula* increase further in the top of this zone presumably representing the events seen in BMP3Ce and BMP4Cc the accompanying drop in *Pinus* is much less dramatic, showing that although there was a clearance of *Pinus* from the New Piece area, *Pinus* is now much more important in the region than was the case 150-200 years ago.

Unfortunately, it is impossible to correlate the second peat core (BMP5) with these recent events because of the break in the sediments. From evidence from the *Pinus* curve it can only be said that assemblage zone

BMP5C ends during the period of heathland, while BMP5D represents part of the period after the establishment of *Pinus* in the area.

4.8 Discussion

The earliest vegetation recorded at the site is a rather open deciduous woodland, rich in *Tilia*. This is consistent with the results from soil pollen studies from nearby sites on the Folkestone beds of the Lower Greensand, namely at West Heath, (Scaife, in Drewett, 1985; and Scaife and Macphail, 1983), Minstead (Dimbleby, 1975) and Iping Common, (Keating, 1983).(A map showing the position of these sites is given in Fig. 4.31.) The results from these studies show that at both these site a similar *Corylus*, *Quercus*, *Tilia* woodland predated the heathland that is seen later.

As well as the above pollen types, *Betula* and *Calluna* were also found in soil pollen assemblages from West Heath. This led Scaife (in Drewett, 1985) to argue that the open woodland conditions thereby suggested, possibly very similar to those represented in BMP3A, were a result of earlier anthropogenic activity, possibly in the Mesolithic. Such activity, could have partially opened a closed deciduous woodland previously present on the local sandy soils. That fact that the BMP3A assemblage shows the presence of such a woodland type, and that is derived from a peat core rather than a soil assemblage adds weight to this argument. The presence of

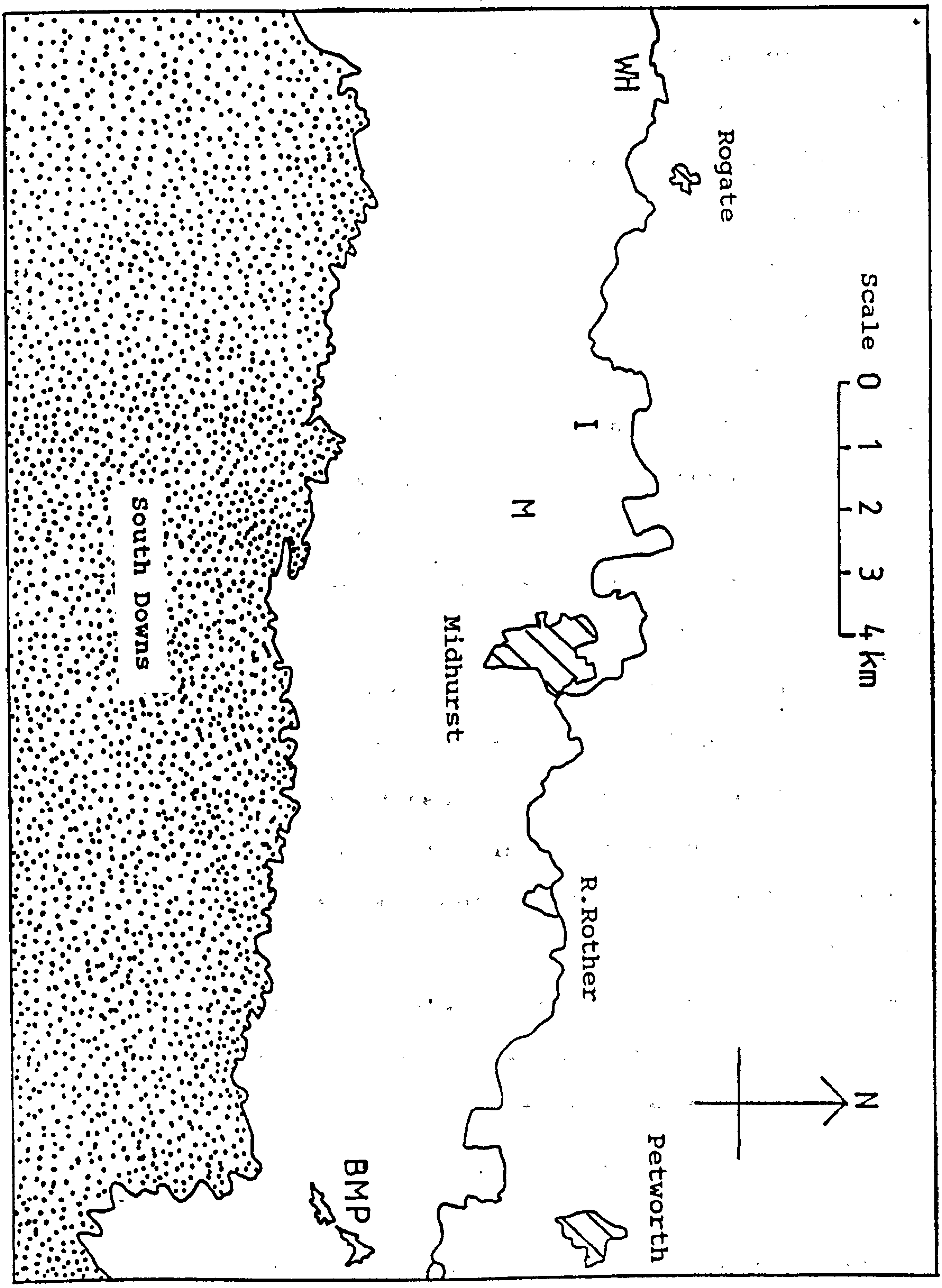


Fig. 4.31 Sites in the vicinty of Burton Mill Pond where soil pollen analyses have been carried out.

Key.

WH- West Heath	M - Minsted
I - Iping Common	BMP- Burton Mill Pond

the *Calluna* and *Betula* in a soil assemblage could be due to faunal mixing or downward movement of pollen through the soil. This is unlikely to be the case in the stratified peats of the valley mire core, which will give a better representation of the contemporary vegetation.

The Bronze Age date for the clearance episode leading to the establishment of heathland is consistent with the general view that many such heaths were established through the activity of Bronze Age man (Dimbleby, 1962), as well as with the results from the local investigations mentioned previously.

The establishment of the heathland seen in BMP3B, would also initiate a change in the local soils from brown earths to the more acidic podzolic soils associated with sandy heaths today. There is evidence of buried podzols which carried heathland, from the bottom of the first Mill Pond core (BMP1) and the second peat core (BMP5), while the sediment making up core BMP4 mainly consists of a podzolic soil, containing a heathland pollen assemblage, overlain by a layer of recent mor humus. It would therefore seem that much of the Folkestone beds in the vicinity of the Burton Mill site carried heathland, including areas now covered by the pond.

However it would be a mistake to assume that the heathland was unchanging throughout this length of time. Evidence, from BMP3 discussed in an earlier section, suggests the partial encroachment of the heath by woodland during one period. Although there is no firm evidence to establish when this lapse in the use (such as grazing) of the heath occurred, it is possible that it represents the period after the departure of the Romans from Britian.

Alder carr could have been present at this site during all the period covered by the cores invetsigated. *Alnus* is the most frequent arboreal pollen type in the original woodland assemblage from the base of the valley mire core. This suggests that the tree was common in the wetter parts of the valley bottom. Other evidence for carr conditions being present before the building of the Mill Pond is given by the two Mill Pond cores. The assemblage BMP2Aa, which represents alder carr is shown by ^{14}C analysis apparently to predate the Mill Pond. *Alnus* is also strongly represented in the soil beneath the lake sediments seen in BMP1, again suggesting *Alnus* was common along the stream in the valley that must have run through the heathland.

Radiocarbon dating suggests that the Mill Pond was originally built around the 13th to 14th Century. It is unlikely that it was originally built for use in the iron industry, the western area of the Weald was the last to be exploited by this industry (Straker, 1931). It is more likely that it was built as an expansion of the existing mill and fishery that were present at the site (such features were metioned in the Domesday Book). The obvious local effect of the building of the pond is upon the local water level, but the lake sediment cores also allow one to gain information about the vegetation from a wider area. Although there are differences between the assemblages from the two cores, such as the high values of *Alnus*, *Salix* and *Ilex* seen in BMP2Ab compared to the low values seen in the BMP1 assemblages, they are due to the local vegetation around the BMP2 sampling site influencing the assemblage. If one disregards these, a similar picture is seen with a presumably regional arboreal spectrum consisting of *Quercus*, *Fagus* and *Betula*, together with the local heathland being represented by the low numbers of *Calluna* pollen seen in both.

The date for the expansion of the Mill Pond (1620-30 A.D ± 65 years), is consistent with the theory that the pond in its current form was built as a power source for the forge known to be present at the site. Again, the extension of the Mill Pond appears to have caused local changes in vegetation due to the rise in the water table such as the change from monocot to *Sphagnum* peats seen at the BMP3B/C interface, and the apparent change in the areas supporting *Alnus* suggested by BMP1D and BMP3Ca. On a more general scale, however, it appears that the area surrounding the pond still carried heathland and there is little evidence for more regional changes. This is of note, as the forge would create a demand for fuel to be used in the processing of the raw pig iron. The normal fuel used in the industry was charcoal, however there is little evidence, except perhaps a slight increase in the values of *Corylus* seen in BMP2B (not seen in BMP1, however), of a change in land management towards wood production. This suggests that fuel could have been supplied from outside of the pollen catchment area of the pond cores. There is however a small area of woodland known as hammer moor, just downstream of the mill pond, which, as the name suggests, could have been associated with the forge.

It seems likely that the loss of much of the heathland from the area of the Mill Pond, leading to the development of woodland, was due to a drop in grazing pressure. However, one can only speculate why this occurred. The two most likely causes are the exclusion of animals through enclosure, or a decline in general agricultural activity linked to a decline in the rural population in the recent past. The subseqent loss of much of the *Pinus* from this area, may be explained by the felling of timber during the Second World War (pers. com. , Reserve Warden).

CHAPTER 5 - HAMMER POND, CHITHURST.

5.1 Site Description.

The site that this core was taken from is a small artificial lake (grid reference SU 847 238) less than 1km to the North East of the village of Chithurst, West Sussex. The pond lies in a steep-sided valley cut into the Hythe Beds outcrop of the Lower Greensand formation, Fig 5.1 shows a geological sketch map of the area. The pond is fed by a stream entering from the north that receives water from a relatively large area of the Weald Clay (see Fig. 2.1).

The pond itself was almost certainly built in conjunction with a forge at this site. Apart from the name, Hammer Pond, other place names from the immediate area include Hammer Plat, Hammer Field, Floodgate Field, Tumbling Bay Field, Hammer Wood, Hammer Stream and Hammer Cottages. These, as well as the presence of blocks of cinder at the site all attest to its industrial history (Straker, 1931).

The position that the core was taken from is shown in Fig. 5.2. The extent of the local woodland is also shown on this diagram. The vegetation at the site today consists largely of *Castanea* coppice on the valley sides leading to the pond, with some mature *Castanea* together with some *Betula*, *Fagus* and *Pinus*, with *Ilex* in the shrub layer. The lake itself is fringed with *Alnus*, while upstream the valley floor is dominated largely by carr

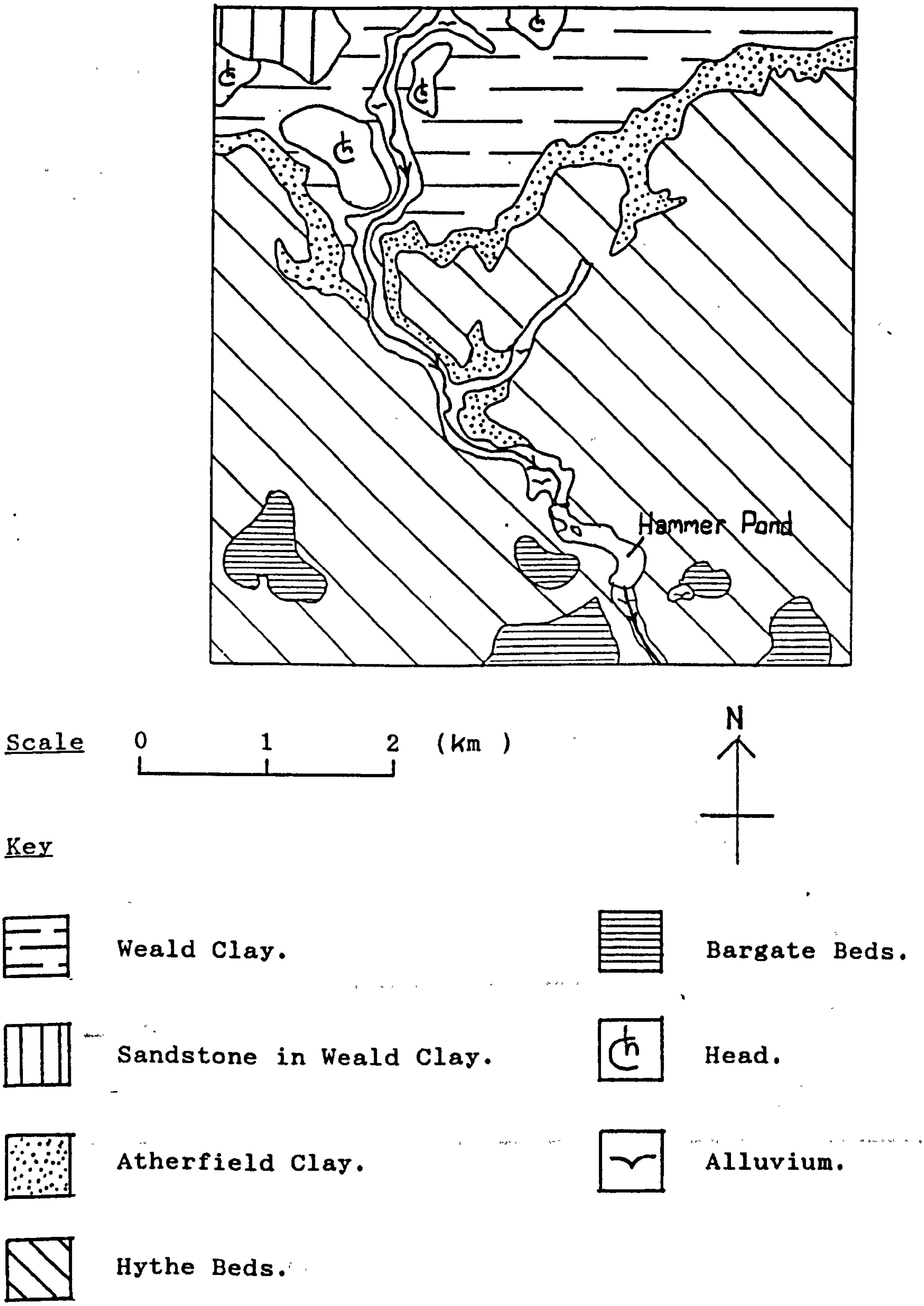
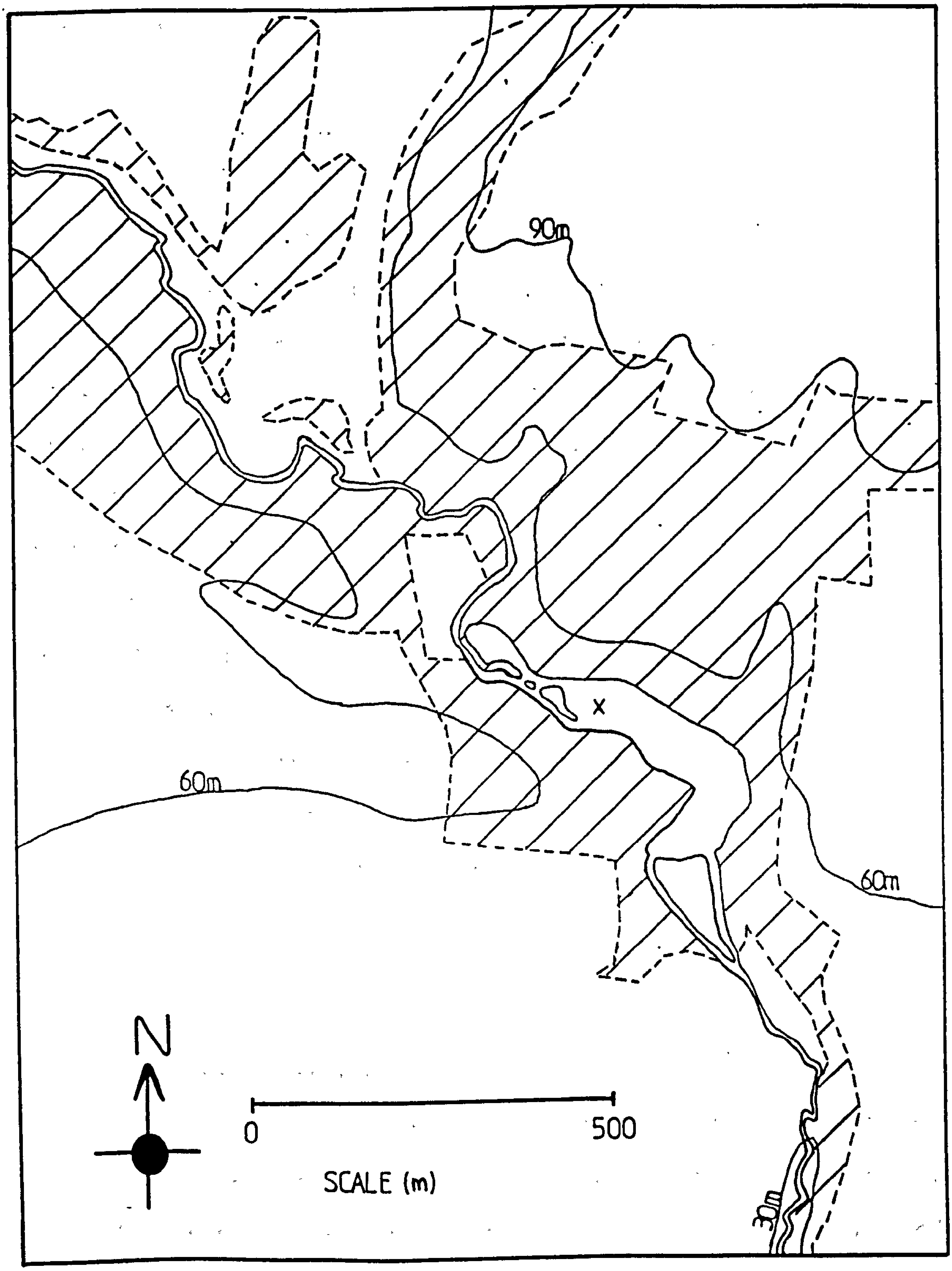


Fig. 5.1 Hammer Pond - geological sketch map.



Key

- Wooded area.

x - Position sediment core was taken.

Fig. 5.2 Hammer Pond - sketch map of site.

conditions rich in *Alnus* and *Salix*.

5.2 Core Description and Results.

5.2.1 Stratigraphy.

0- 10cm Leaf litter.

10- 54cm Lake mud with poorly humified plant debris.

54-201cm Lake mud with some humified plant debris.

201-215cm Lake mud with inwashed sand.

215-283cm Lake mud.

283-284cm Dark organic matter.

284-286cm Lake mud.

286-287cm Sand.

287-312cm Lake mud.

312-313cm Dark organic matter.

313-322cm Lake mud.

322-323cm Dark organic matter.

323-324cm Sand.

324-330cm Lake mud with sand inwash.

5.2.2 Pollen Stratigraphy.

This core was sub-sampled every 4cm. At least 500 pollen grains and spores were counted from each sample. In the summary and main pollen diagrams, Figs. 5.3 and 5.4 the results are expressed as percentages of total pollen and spores (T.P.). Those pollen types recorded from this core that are not included in the main pollen diagram are shown in Table 5.1.

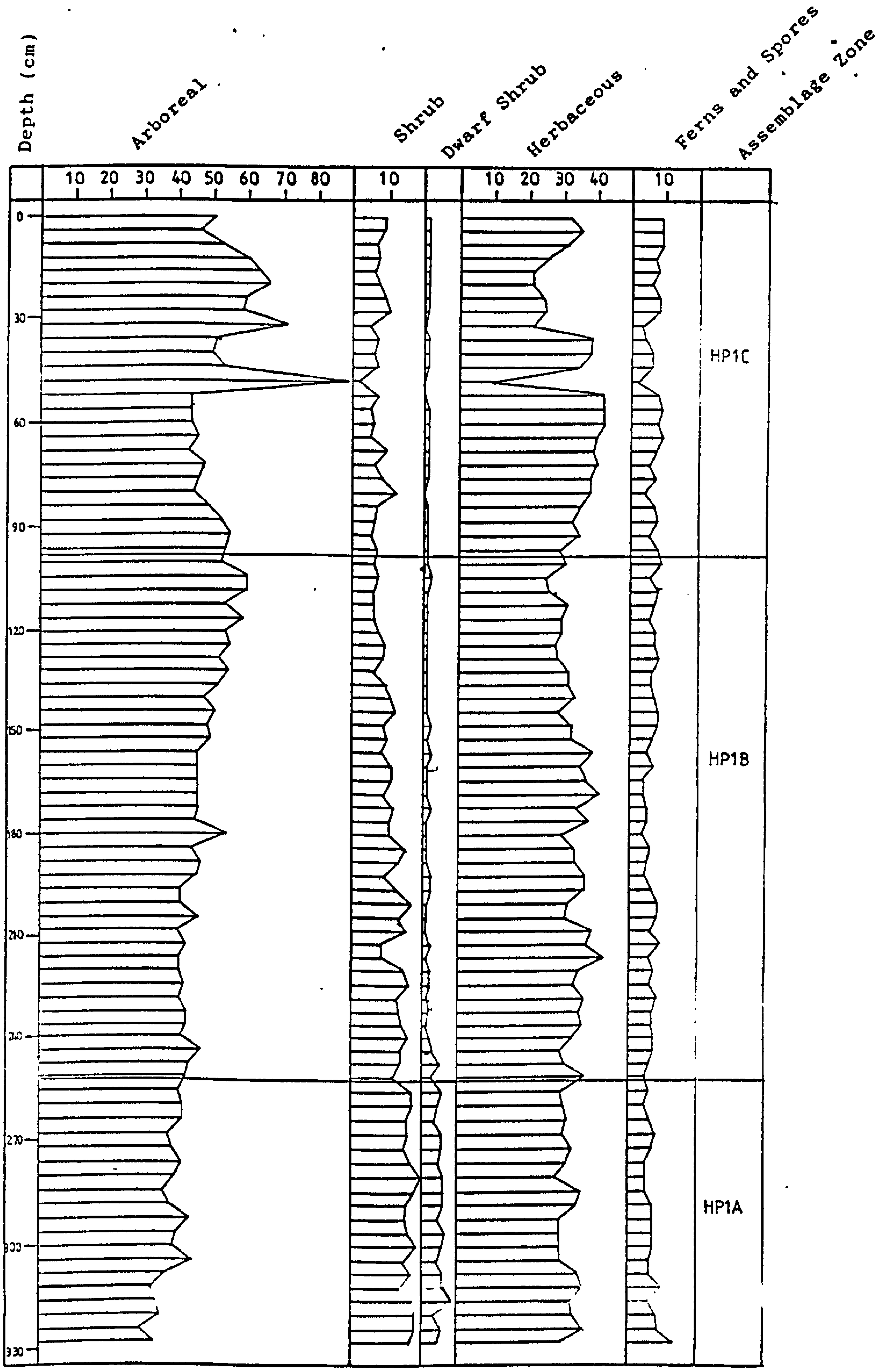


Fig. 5.3 HP1 Summary Pollen Diagram

(Values expressed as percentages of sum of total pollen and spores.)

Fig. 5.4 HP1- Main Pollen Diagram

All values expressed as percentages of the sum of total pollen and spores.(+ represents values <1%)

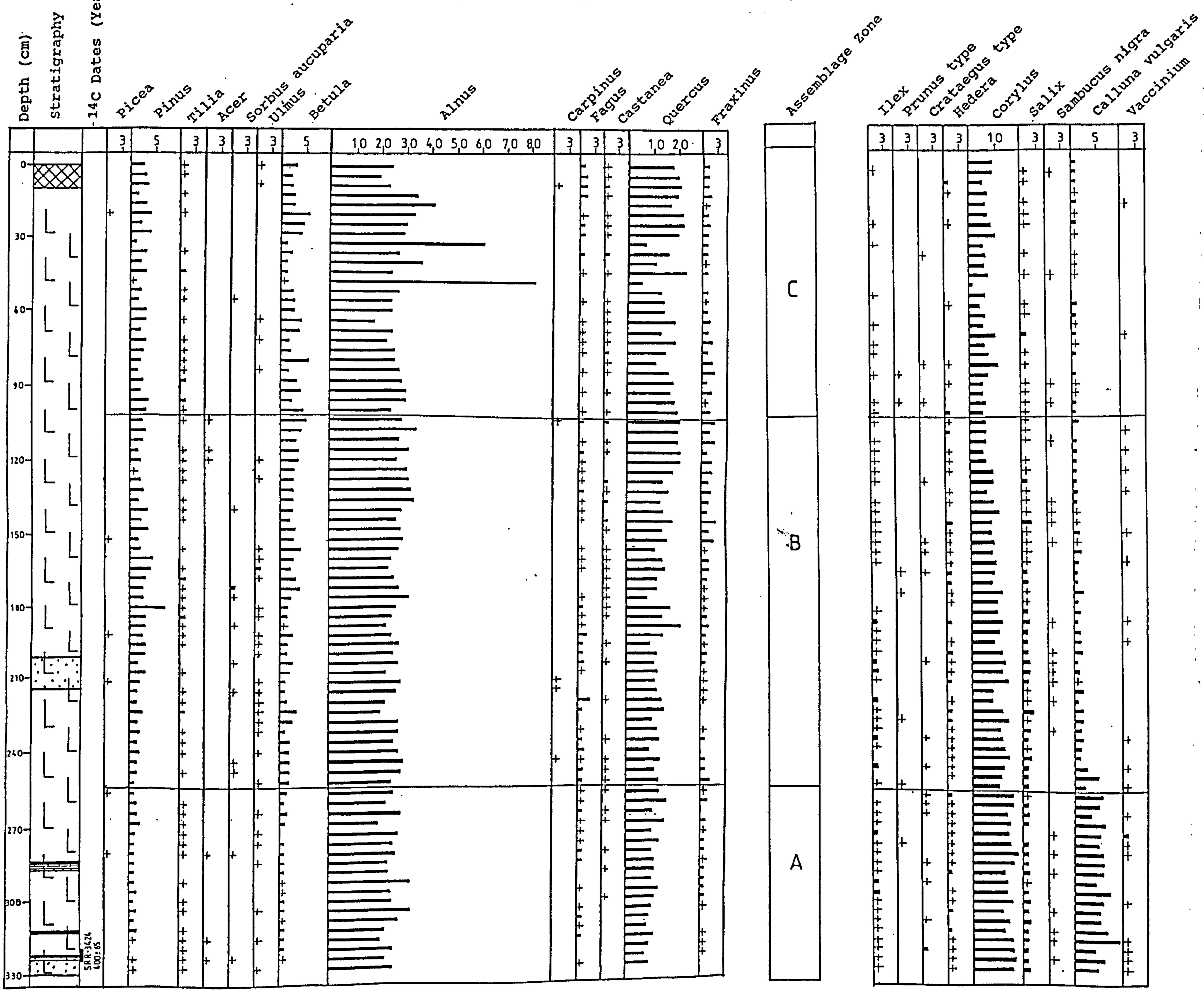
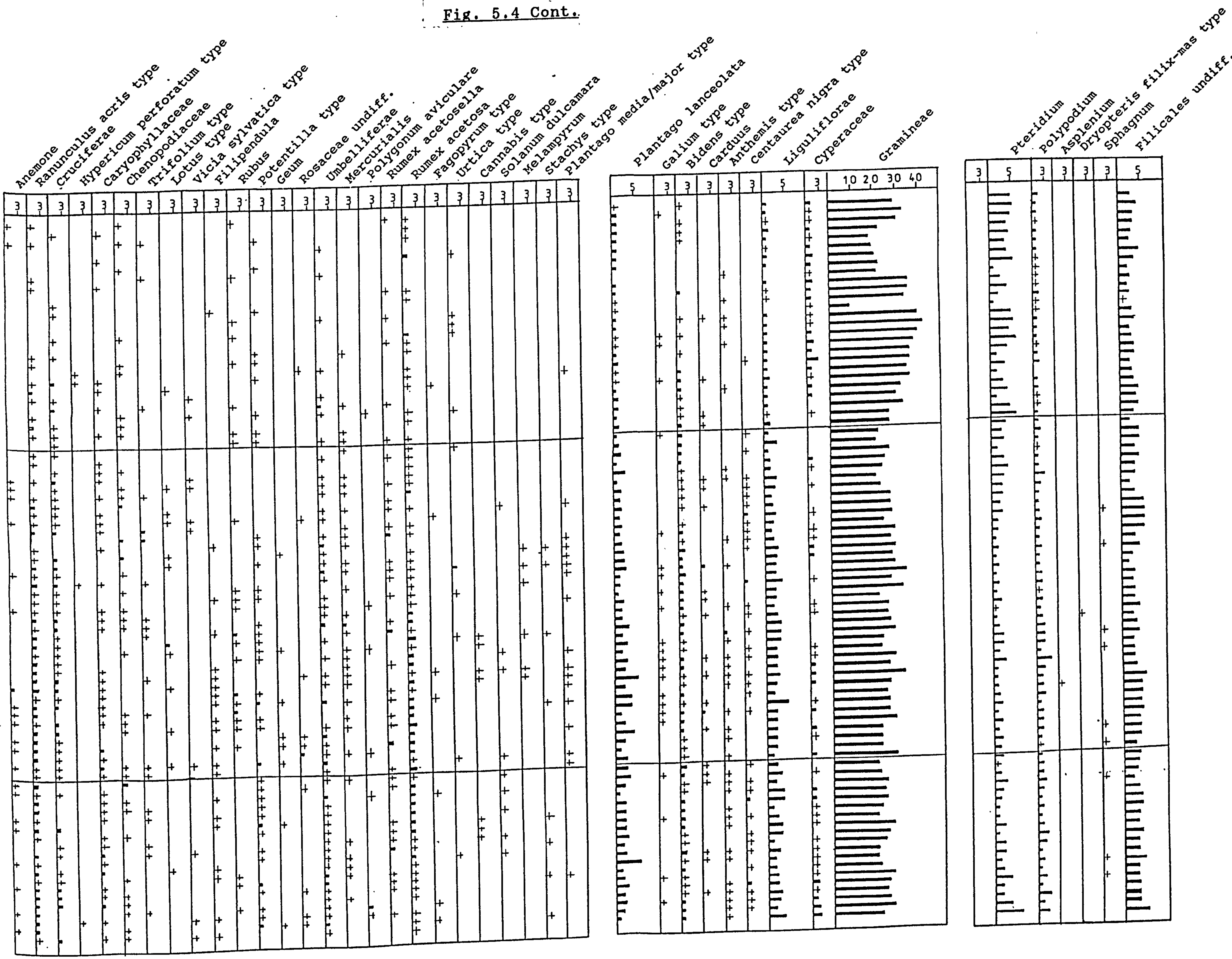


Fig. 5.4 Cont.



Anemone
Ranunculus acris type
Cruciferae
Hypericum perforatum type
Caryophyllaceae
Chenopodiaceae
Trifolium type
Lotus type
Vicia sylvatica type
Filipendula
Rubus
Potentilla type
Geum
Rosaceae undiff.
Umbelliferae
Mercurialis
Polygonum aviculare
Rumex acetosella
Rumex acetosa
Fagopyrum type
Urtica type
Cannabis type
Solanum dulcamara
Melampyrum
Stachys type
Plantago media/major type
Plantago lanceolata
Galium type
Bidens type
Carduus
Anthemis type
Centaurea nigra type
Liguliflorae
Cyperaceae
Gramineae
Pteridium
Polypodium
Asplenium
Dryopteris filix-mas type
Sphagnum
Filicales undiff.
10 20 30 40

Fig. 5.4 Cont.

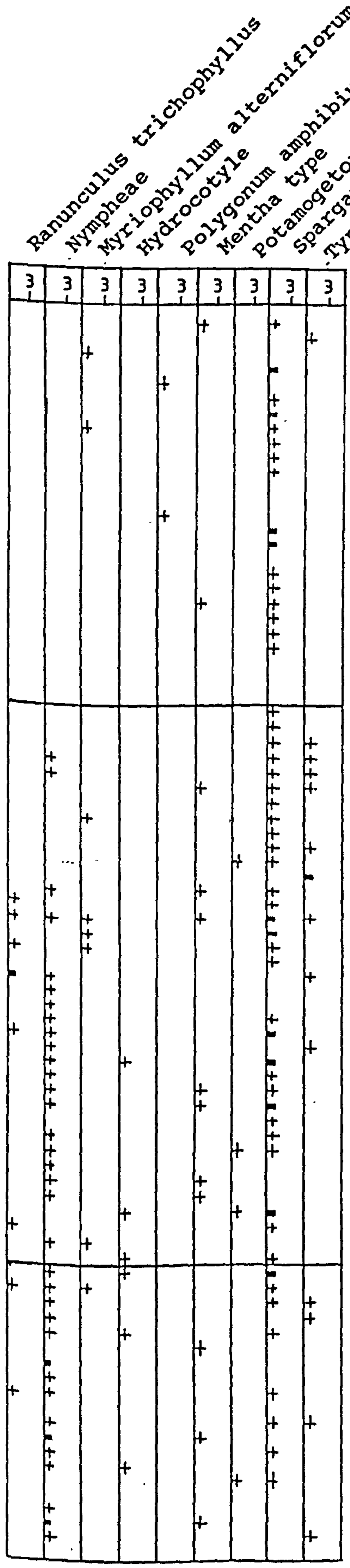
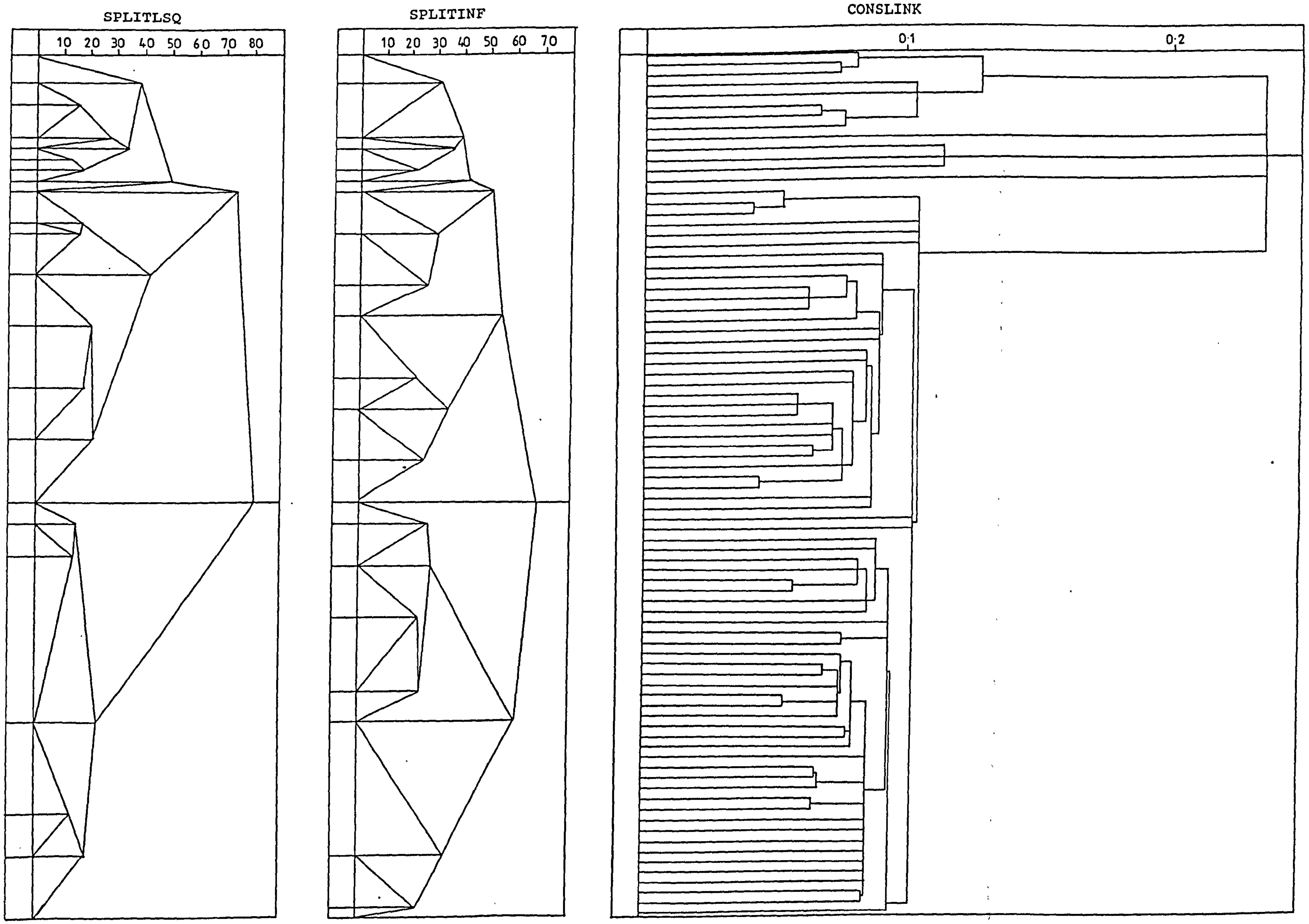


Fig. 5.7 HP1 Results of the Zonation program.



DEPTH (cm)	POLLEN TYPE
4-5	*Impatiens*
8-9	*Impatiens, Rumex obtusifolius*
12_13	*Cirsium*
24-25	*Teucrium*
32-33	*Onobrychis* type
36-37	Leguminosae undiff., *Rumex obtusifolius*
60-61	*Rhinanthus* type, *Cirsium*
64-65	*Serratula* type
72-73	*Succisa*
80-81	*Cirsium*
88-89	*Aster* type, *Centaurea* spp.
100-101	*Myosotis* type
104-105	Scrophulariaceae type
108-109	*Aster* type
116-117	*Epilobium* type, *Polygonum bistorta* type
120-121	*Polygonum bistorta* type, *Rhinanthus*
124-125	*Rumex obtusifolius*
128-129	*Sorbus* undiff, *Artemisia*
132-133	Leguminosae undiff, *Artemisia*
140-141	*Bupleurum* type
144-145	*Polygonum bistorta* type, *Veronica*

Table 5.1 Pollen types found in the Hammer Pond core not included in the main pollen diagram.

148-149	*Ligustrum*
152-153	*Symphytum, Valeriana dioica*
156-157	*Valeriana dioica*
168-169	*Juglans, Genista* type
172-173	*Rhinanthus* type
180-181	*Lythrum portula*
188-189	*Rhamnus catharticus, Papaver*
192-193	*Ligustrum*
212-213	*Polygonum persicaria* type, *Solanum nigrum, Aster* type
220-221	*Veronica*
228-229	*Polygonum bistorta* type
240-241	*Rhinanthus* type
244-245	*Rumex obtusifolius*
256-257	*Genista* type, *Veronica, Teucrium*
260-261	*Rosa, Artemisia*
264-265	*Rhamnus catharticus, Centaurea cyanus*
272-273	*Ulex* type
276-277	*Sorbus* undiff
280-281	*Ulex* type, *Rosa, Artemisia*
284-285	*Ononis* type
292-293	*Polygonum persicaria* type
300-301	*Caltha* type
308-309	*Ligustrum, Artemisia*
312-313	*Plantago coronopus*
316-317	*Rhamnus catharticus, Frangula*
320-321	*Aster* type

Table 5.1 cont.

5.2.3 Numerical Analysis.

The taxa used in the computer programs were as follows: *Pinus*, *Betula*, *Alnus*, *Quercus*, *Fraxinus*, *Corylus*, *Salix*, *Calluna*, *Plantago lanceolata*, Ligulifloreae, Gramineae, *Pteridium*, *Polypodium* and Filicales.

The results are given in Figs. 5.5 to 5.7.

5.2.4 Local Pollen Assemblage Zone Descriptions.

The most striking feature of this pollen diagram is its apparent uniformity, with a limited number of pollen types dominating throughout the whole diagram. This is reflected in the results of the mathematical analysis of the data set. The SPLITINF and SPLITLSQ plots (Fig. 5.7 a and b) both show the most important division in the diagram to be at depth 170cm between sample numbers 43 and 44. However no very obvious change in the pollen spectrum is seen at this point. Therefore this split must be interpreted as an artifact of the algorithm of the mathematical programs reflecting this general uniformity through the diagram, by simply dividing the diagram almost exactly in two. For this reason this split was not used in the division of the diagram into local pollen assemblage zones. The CONSLINK plot (Fig. 5.7c) again apparently shows that most of the samples are relatively similar, except for a number near the top of the diagram.

It is the results of the DECORANA analysis that best reflect the nature of this pollen diagram. The general

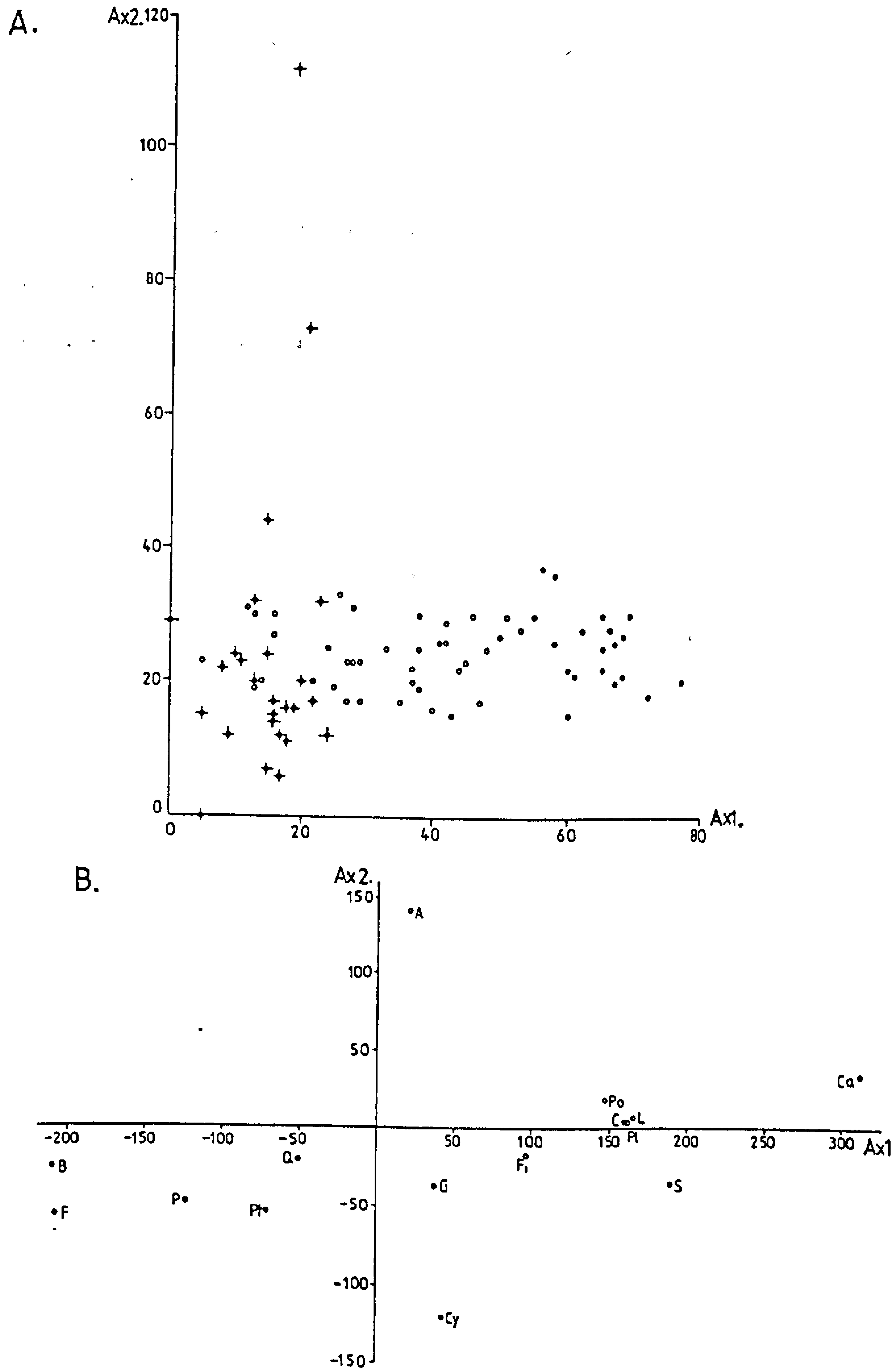


Fig. 5.5 HP1-DECORANA A-Samples B-Species

(Key overleaf)

Fig. 5.5 (cont.)

Key.

A: Samples

● Assemblage zone HP1A

○ Assemblage zone HP1B

⌖ Assemblage zone HP1C

B: Species

P - Pinus	S - Salix
B - Betula	Fi- Filicales
A - Alnus	Pl- Plantago lanceolata
F - Fraxinus	L - Liguliflorae
Q - Quercus	G - Gramineae
C - Corylus	Pt- Pteridium
Ca- Calluna	Po- Polypodium

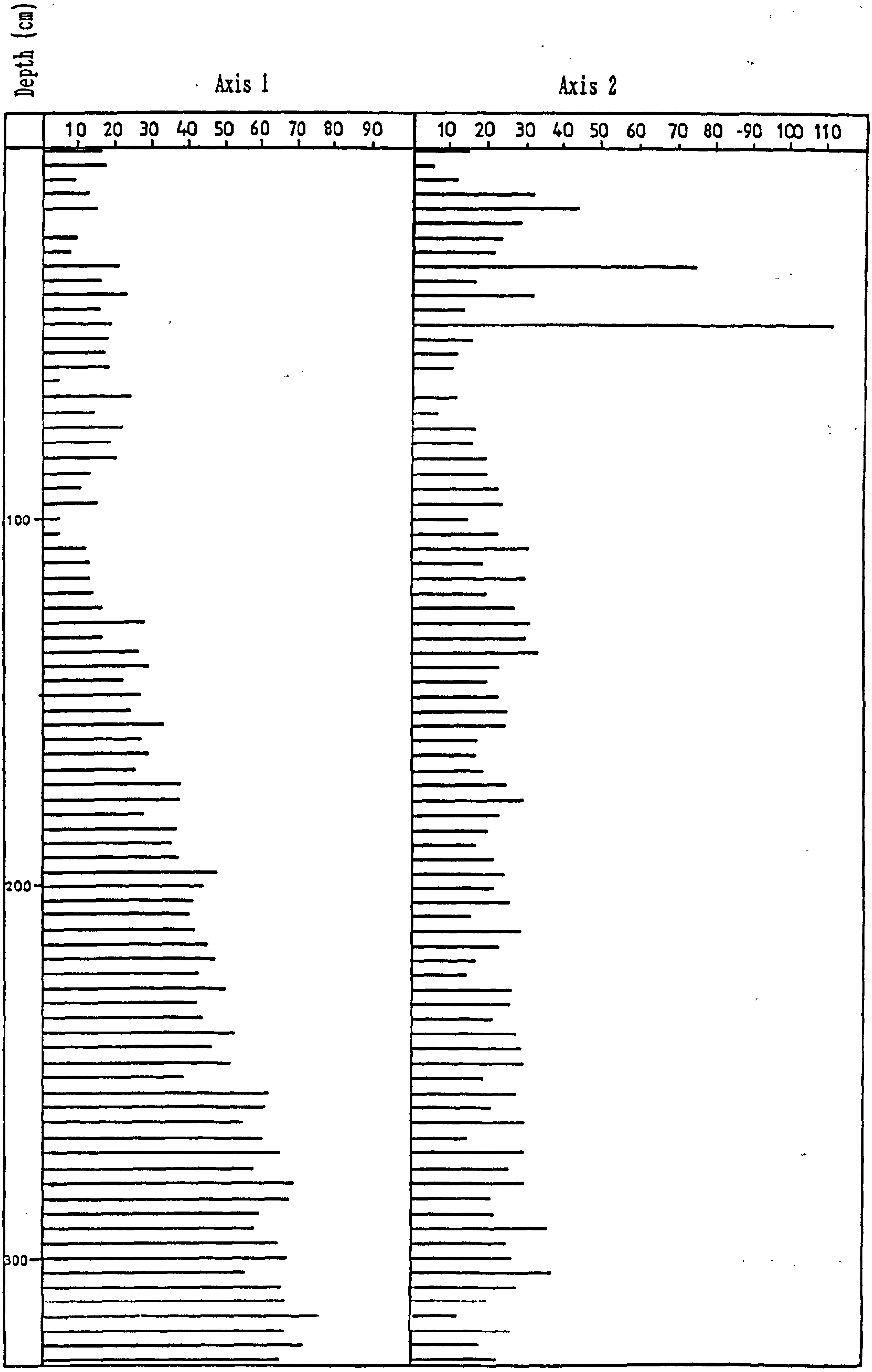


Fig. 5.6 Hammer Pond DECORANA sample scores x depth.

uniformity of the pollen diagram is reflected if axes 1 and 2 of the sample scores are plotted together (Fig. 5.5a). Here a single elongate cluster of samples scores can be seen with a few outlying points. However, if these axes scores are plotted separately against depth (Fig. 5.6) the major features of the diagram are most clearly revealed. The axis 1 scores show the important changes. From a period of relatively stable high scores, the axis 1 values drop steadily until about sample 27. After this point the scores are again relatively stable, but the values low. Reference to the DECORANA species plot (Fig. 5.5b) show that high axis 1 scores are most notably associated with *Calluna, Corylus, Plantago lanceolata* and Liguliflorae pollen types. Low axis 2 scores are most closely associated with *Betula, Fraxinus* and *Pinus*. The most notable feature of the Axis 2 scores is the similarity of its shape when plotted against depth with that of the *Alnus* curve. It can also be seen from Fig. 5.6 that *Alnus* is strongly associated with high axis 2 values, while most of the other pollen types are more or less neutral in respect to this axis. This shows that simply the fluctuations seen in *Alnus* are alone an important source of variation, and this variation is independent of the other pollen taxa. It can therefore be seen that axis 1 of DECORANA is the best aid to zonation and interpretation.

Zone HP1A. Depth 330-254cm.

The upper boundary of this zone, the split between samples 65 and 64, not only marks the end of relative stability in the DECORANA axis 1 plot but is shown to be the most important division in the lower portion of the diagram by both SPLITINF and SPLITLSQ.

Alnus is numerically the most important taxon in this zone. Although generally stable, averaging 26% T.P., some fluctuations between 20% and 33% T.P. are seen. *Quercus* is also important, showing a trend to increase slightly through the zone, reaching a maximum of 16% T.P. near the top.

Both *Pinus* and *Betula* are only present in very low numbers, neither of these taxa achieving a total as high as 2% T.P..

The most diagnostic features of the zone however, are that the amounts of *Corylus* and *Calluna* pollen present are at their highest. *Corylus* is relatively stable, averaging 15% T.P., while the values of *Calluna* show some varation between 4% and 10% T.P..

Gramineae dominate the herbaceous pollen types, but numbers drop slightly through the zone from a maximum of 27% T.P. near the start of the zone to 20% T.P. by the end. Many different herbaceous pollen taxa are recorded, the most numerous being Liguliflorеae and *Plantago lanceolata*.

Zone HP1B. Depth 254-103cm.

This assemblage zone corresponds to the portion of the DECORANA axis 1 plot where their values show a consistent period of decline.

From the summary pollen diagram (Fig. 5.3), it can be seen that the main features of this assemblage zone are the gradual increase in the numbers of the arboreal taxa and the decline in shrubs and dwarf shrubs.

Alnus, *Quercus*, *Fraxinus*, *Betula* and *Pinus* can all be seen to increase during this zone. *Alnus* is still the most important arboreal pollen type, but only shows a relatively small increase through the zone from peaking at 35% T.P. towards the top of the zone. From amounts similar to those seen in HP1A, *Quercus* shows a more noticeable increase, reaching values of around 20% T.P. by the end of the assemblage zone. The amounts of *Betula* are consistently higher in this zone than the previous one, reaching a peak of 5% T.P. in the uppermost sample, while *Fraxinus* is most frequent in the upper half of this assemblage zone, present at values around 2% T.P.. *Pinus* increases in the first half of the zone, reaching values between 3% to 7% T.P., but then seems to drop slightly in importance during the latter part of the zone.

The decline in the values of the shrub pollen is mainly due to a gradual drop in importance of *Corylus* through the zone, although *Salix* is also less frequent in the top half of the assemblage.

The fall in *Calluna* is more rapid, from a peak of 5% T.P. near the start of the zone it quickly drops to values below 2% T.P. where it remains through the rest of this assemblage.

Gramineae remains relatively constant in this zone, fluctuating between 20% and 33% T.P., averaging 25%

T.P.. Generally the other important herbaceous taxa are those seen in HP1A, showing similar values at the start of this zone, although generally they seem to decline slightly in importance towards the top of this assemblage.

Pteridium spores increase in frequency towards the top of this zone , reaching a maximum of 3% T.P. Filicales values are slightly depressed in the mid section of this zone, but recover in the later portion. The only notable feature in the aquatic spectrum is that *Typha latifolia* occurs more frequently in the upper half of the zone.

Zone HP1C. Depth 103-0cm.

This is the most ill-defined of divisions. It reflects the point at which the axis 1 DECORANA score stop falling.

Excluding the peaks of 62% and 83% T.P., *Alnus* fluctuates around an average value of 28% T.P.. *Quercus* and *Betula* both show a greater degree of variation than seen in the previous zone. *Quercus* fluctuates between 5% and 22% T.P. while *Betula* varies between less than 1% and 5% T.P..

Corylus varies between 1% and 11% T.P., but on average is present in lower amounts than in the previous zone. *Calluna* is present more sporadically, rarely accounting for over 1% T.P..

When excluding Gramineae, it can be seen that the numbers of herbaceous pollen types have dropped in this zone. *Plantago lanceolata* and Liguliflorae reflect this; neither accounts for more than 1% T.P. through the zone. Cyperaceae is the only exception to this trend, appearing far more regularly in this zone. Through the first half of the zone the amounts of Gramineae increase, reaching a maximum of 41%, but this taxon is less important in the second half. *Pteridium* is at its most numerous in this zone, often achieving scores of over 5% T.P..

5.2.5 ^{14}C Analysis.

One sample from this core was selected for ^{14}C analysis. This sample, SRR-3424, taken from the lake sediments of depth 320-325cm was treated to yield acid (0.5mM HCl) insoluble organic detritus and gave a date of 400 ± 65 years B.P.. The position and date of this sample is also shown on the main pollen diagram (Fig. 5.4).

5.2.6 Local Pollen Assemblage Zone Interpretation.

The ^{14}C dated sample (SRR-3424), from the lower region of this assemblage zone which gave a date of 400 ±65 years B.P., suggests that the pond was built in the late medieval/Elizabethan period. This result is consistent with the hypothesis that the lake was built to provide an energy source for an iron hammer, as the iron industry is known to have been active in this area at that time. Over three metres of sediment have accumulated during this period, suggesting a relatively fast sedimentation rate, but the absence of other dates from this site means that it is impossible to ascertain whether this accumulation rate was constant throughout the history of the pond.

The size of the pollen catchment area must be considered in the interpretation of the pollen diagram. The amount of pollen entering via stream input could be proportionately large, and it is possible that pollen entering the pond in this manner could be derived for a relatively large catchment area (see Fig. 2.1). However, as the pond is situated at the bottom of a steep-sided valley, high amounts of locally derived pollen could also be entering the pond. Pollen released into the air from plants in the valley is unlikely to be carried out, but will tend to fall towards the valley bottom. Also, the sloping sides of the basin will enhance surface water runoff, which will increase the proportion of pollen entering the pond via this drainage water route. Again, due to the topography of the site it is probable that only low amounts of pollen derived from more distant sources will enter the system via the air.

Therefore, although a high proportion of the pollen will reflect the vegetation of the local valley, it is possible that pollen from more distant communities, possibly of the Weald Clay, may also be represented.

Zone HP1A.

The high values of *Alnus* pollen are simply interpreted. This pollen is derived from trees either growing around the pond itself, the wet carr conditions of the valley bottom upstream of the site, or from stream-side trees further afield. Trees growing in such places will release large amounts of pollen directly into the pond or into the streams feeding the pond. The records of *Salix, Rhamnus* and *Frangula* could also represent members of a carr community.

Apart from the importance of arboreal pollen types, the frequent records of *Ilex, Hedera, Anemone* and *Mercurialis* pollen types and *Polypodium* spores suggest the presence of woodland rather than scattered individual trees. Generally *Quercus* is the most important tree in the area. However, the importance of *Corylus* pollen in the assemblage suggests that any woodland present did not consist totally of a closed *Quercus* canopy. The woodland in the area must have been managed at least in part as coppice-with-standards, with *Corylus* present in the underwood (coppiced) component, for a significant amount of *Corylus* pollen to be produced (see Appendix 1). It is unlikely that areas of natural *Corylus* scrub would remain in the area, in the heavily managed post-Medieval landscape. It cannot be assumed that in any coppicing practiced, *Corylus* was the only species being used as underwood. Many species of tree could be utilised as underwood, including species normally regarded as timber trees such as *Quercus* and *Fraxinus*. However, their use as underwood would not be detected in the pollen record. It is unlikely that such slow maturing trees will be able to produce flowers within the length of the average coppice cycle,likely to be between 10-15 years (Rackham, 1980, states the average length of a coppice cycle was 6 years in the 13th Century, and rose to 15 years by the 19th Century). Even if they do so, any pollen produced will be impossible to distinguish from that of the standard, or other mature trees.

The forge, for which this pond was constructed, was almost certainly operating during the period covered by this assemblage zone. To run the forge economically a local, cheap, renewable source of fuel wood be needed. An obvious supply of this fuel would be from coppiced woodland. This can be seen as supporting the theory that the *Corylus* present in this assemblage does derive from the underwood component of such a system. If the local woodland was simply clear-felled to provide fuel, this valuable resource would soon be exausted and fuel would then have to be transported to the site from further afield. This would decrease the financial viability of the forge. There is also no evidence for such a clearance in this assemblage. Possible documentary evidence for such a local fuel source comes from the name of the woodland north-west of the pond, along the valley of the stream feeding it, Hammer Wood, which suggests that this area of woodland was associated with the forge.

Fraxinus, especially when its low pollen representation is taken into account, appears to be relatively numerous. But the other trees represented are probably only minor elements in the vegetation. The *Pinus* curve is of note. However, this pollen type is only regularly found in any numbers some time after the start of the diagram. This point could represent the first plantings of this tree in the area.

The high numbers of Gramineae pollen in the assemblage, could indicate that significant areas in the catchment are free of woodland cover. Only a preliminary size-class analysis of the Gramineae pollen was carried out at this site, with not every level being represented. The results of this study is given in Fig. 5.8. It is possible that a proportion of the Gramineae pollen is derived from grasses, such as *Phragmites*, growing in wet conditions near to the sampling site. However, the relative importance and diversity of herbaceous and dwarf shrub pollen types add weight to the theory that significant areas of the pollen catchment were open.

Although the values of *Calluna* pollen are relatively low when compared to the numbers of arboreal types, it is possible that they represent an important element in the local vegetation. As mentioned in the previous chapter, work by Bonny (1976) has shown that *Calluna* is poorly represented in pollen assemblages derived from lacustrine sediments, even when a lake is surrounded by vegetation dominated by this species. This suggests that there could be considerable areas of heathland in the catchment. Other pollen types in this assemblage zone that could support this hypothesis include *Vaccinium*, *Genista* type and *Rumex acetosella*. Because of the geology of the area, any heathland in this catchment will most likely be on

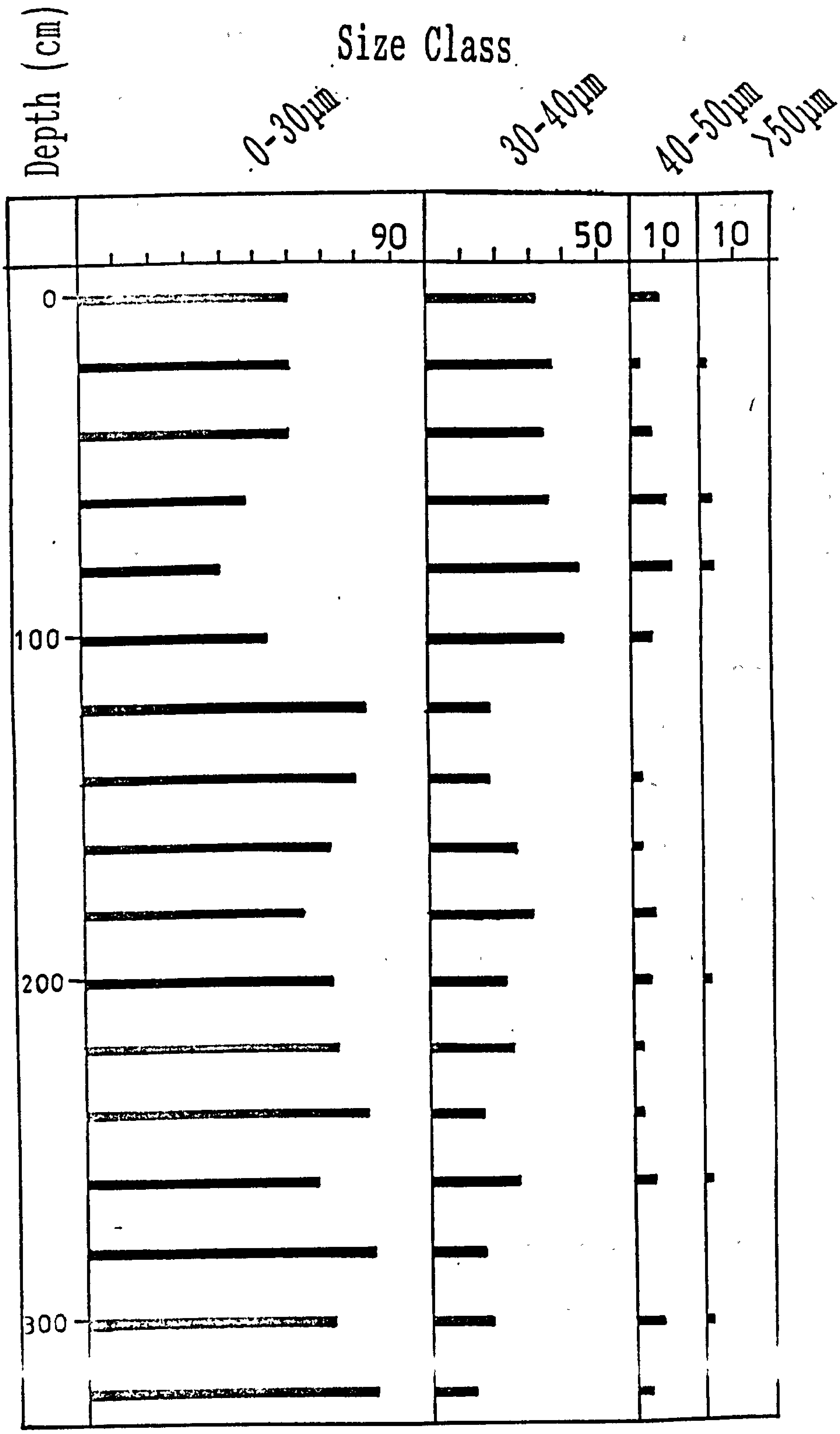


Fig. 5.8 HP1 Gramineae size class analysis.

(Values expressed as percentages of total Gramineae pollen.)

the Hythe Beds of the Lower Greensand, rather than the Weald Clay. A local example of an area of heathland present today on the Hythe Beds is given by Woolbeding Common, just to the north-east of Hammer Pond. However, it is not impossible that some heathland was present in the Weald clay area, especially where there are sandstone outcrops.

There are a number of possible indicators of agricultural activity in this assemblage. The importance of *Plantago lanceolata* and records of *Rumex acetosa* and *Ranunculus acris* type suggest that areas of pastoral activity are present. The frequent records of a number of other pollen types icluding; Liguliflorae, *Bidens*; *Trifolium* and Caryophyllaceae may also indicate pastoral activity, but, these pollen types could also indicate other agricultural practices (Behre, 1981). The size-class analysis of the Gramineae pollen shows the presence of possible cereal grains, and these, together with the records of *Fagopyrum*, *Centaurea cyanus* and *Polygonum persicaria* pollen types are possibly indicative of arable activity. It is also possible that the records of *Cannabis* type pollen could be derived from crop plants, but it should be noted that *Humulus lupulus*, not distinguished from this pollen type, is found as part of the valley floor vegetation today.

Zone HP1B.

The decline in the numbers of *Calluna* pollen seen at the beginning of this zone, suggests heathland in the area is being lost. That *Betula*, and to a lesser extent *Pinus* begin to increase at this point raises the possibility that the heathland could have been invaded by trees. As in the case of the former heathland at Burton Mill, changes in heathland management, such as a drop in grazing pressure, would be the most probable cause of this change.

Calluna pollen is still recorded regularly in the rest of the zone which raises the possibility that *Calluna* could also be present as a shrub/ground layer plant in open woodland. If this were the case, it may indicate that such areas were managed as wood-pasture. The term wood pasture can cover a wide range of land usages, but a basic definition is given by Peterken (1981), who defines it as woodland which is permanently available as pasture , or pasture with trees. This system of land use is less stable than woodland (Rackham, 1980), as a balance must be kept between trees and grazing. Too much tree cover impairs grazing, while if grazing is too heavy, regeneration of trees will be reduced. There are a number of solutions for this, wood-pasture could be compartmented, that is separate areas for trees and grazing could be created. Or if the wood-pasture were uncompartmented, the use of nurse trees resistant to grazing, such as *Ilex aquifolium*, *Prunus spinosa*, *Rhamnus catharticus*, *Rosa* spp. and *Juniperus communis*, would protect young trees (Pott, 1989). But perhaps the most common solution was the use of pollards. If a tree is pollarded it can be regularly cropped for wood and its life span is also extended, avoiding the need for establishment of new trees in the area.

It is of note that Behre (1981) mentions *Calluna* pollen as a possible indicator of wood-pasture. Many of the other pollen types mentioned by Behre as representative of this group are present in this assemblage. These include *Pteridium*, Umbelliferae, Liguliflоreae, *Artemisia* and *Trifolium*. However, these pollen types could also be derived from other situations. The records of *Melampyrum* in this assemblage zone may be a better indicator of wood-pasture. Behre suggests that it is not associated with other farming practices. However even this pollen type could be derived from other situations such as oak coppice or from bog surface communities. As Moore (1980) states, it is difficult to use pollen to ascertain the nature of herbaceous communities as pollen identification is often only possible to crude taxonomic levels. Even if exact identification is possible, a single species may grow in a wide range of situations.

The most important feature of this zone, however, is the decrease in the amounts of *Corylus* and many of the herbaceous taxa, and the increase in the values of a number of arboreal pollen types. This is best illustrated in the DECORANA axis 1 against depth plot. As previously mentioned, the increases in *Betula* and *Pinus* could be in part due to the invasion of former heathland. However, changes in the management of the woodland in the area could be responsible for much of the change. The drop in the levels of *Corylus* suggests there could have been a decline in the importance of coppicing in the area. The abandonment of an area of coppice would have a marked effect on its pollen output. If, as was commonly the case, other species as well as *Corylus* formed a part of the underwood, on the cessation of cutting the stools these species would be able to grow further towards maturity. This would have two major effects, firstly these trees would overtop the *Corylus* in the system and suppress its flowering. Secondly, even if previously unable to flower, these maturing trees would start to produce flowers and hence pollen. It is possible that the increases in the amounts of *Quercus* and *Fraxinus* seen in this zone could be due to such a process.

The shape of the *Corylus* curve, especially in the earlier stages of this zone, is rather unusual in that the values of this pollen type can be seen to rise and fall in an almost regular fashion. Whether such a pattern is a reflection of different stages in a coppice cycle, is open to speculation. Normally, coppice is managed in a way so that a proportion of the area was rotationally cropped each year, which would lead to a more or less constant level of pollen output each year (see Appendix 1). However if the area was not managed in such a manner, but cropped in a less regular fashion, this could lead to the pollen output varying over time. This may lead to the fluctuations seen in the *Corylus* curve. If this is the case, it would be expected that the 'period' of the fluctuations in the curve would roughly correspond to the length of time of a coppice cycle. The interval between 'peaks' in the *Corylus* curve (for example the samples at depths 208, 224 and 240cm) averages around 15cm. If one assumes that the sediments accumulated at a uniform rate (caution must be expressed here, as there is no evidence to support this other than that the sediment type changes little through the core), it can be worked out from the radiocarbon date associated with this core, that 1cm of sediment could represent between 1.2 and 1.6 years. This would put the time interval between the 'peaks' at between 17 and 23 years. This is slightly longer than the average coppice cycle, but not out of the bounds of possibility, especially if one takes into account the fact that mixing of the upper sediments leads to any one sample representing an average of a number of years pollen input (Davis, 1968). Other explanations of the shape of the *Corylus* curve include climatic conditions, for these could favour flowering more some years than others. Alternatively the fluctuations may simply be a statistical artifact of the pollen sum (a study of absolute pollen influxes into this site could shed more light on this question).

It must be noted, however, that coppicing is still carried out in the area today, including on the slopes leading to the pond itself. But, *Castanea* is now the predominant underwood species and it is possible that other underwood species were replaced by *Castanea* in this period. *Castanea* pollen is more frequently recorded in this zone than in HP1A. Again, if one assumes a relatively constant sedimentation rate, it is possible to speculate that this change could have started as early as the 17th Century. However this pollen could be from standard trees, of which a few are present in the area today, rather than from coppiced individuals which may not even be able to flower during the length of a coppice cycle.

Although *Alnus* does not increase as markedly through this zone as some of the other arboreal species, its values do show a degree of variation throughout this zone. These fluctuations can be seen to be similar to those discussed in relation to *Corylus* earlier. It is again possible that such variation is a reflection of coppicing of this species, especially of trees in the immediate vicinity of the Hammer Pond itself. Alder trees can be found growing around the margins of the pond today that show evidence of having been coppiced. However, similar caution to that expressed in relation to *Corylus* must be exercised.

Changes in wood-pasture could also lead to an increase in arboreal pollen types, and may account for a drop in the levels of some herbaceous taxa. A fall in the degree of grazing in such a system would lead to changes in vegetation. The regeneration of trees could be enhanced, leading to a greater degree of shading which would supress the herb layer. It is also possible that the cessation of grazing could change the structure of the herb layer. If grasses were not being continuously grazed they could attain a greater height, flower more heavily, and lower the diversity of other herbaceous plants through greater competition. The increase in the importance of *Pteridium* spores seen in this zone could be due to changes in wood-pasture. Reduced grazing pressure, and especially trampling could allow this species to expand.

As seen in HP1A, a number of possible indicators of both arable and pastoral practices are recorded in this zone. Possible arable indicators not recorded previously include a pollen grain of *Papaver* type, and *Bupleurum*. Members of the genus *Bupleurum* are rare today. However, one species *B.rotundifolium* is associated with cornfields. The record of *Polygonum bistorta* is a further possible indicator of pastoral activity as it is often associated with meadows.

Zone HP1C.

The changes seen through the previous zone have now apparently ceased and the DECORANA axis 1 plot suggests that this zone seems to represent a period of more stable vegetation. Perhaps the most striking feature is the rise then fall of Gramineae pollen. This feature is accompanied by a decline in arboreal pollen values, most clearly seen in the summary pollen diagram (Fig. 5.3). The values of other herbaceous pollen types do not increase with the Gramineae; their amounts are lower than in the previous zones and less taxa are recorded. The values of *Pteridium* also expand in this zone suggesting that, rather than these features representing an increase in the amount of pastoral land in the area brought about through woodland clearance, they could indicate a further drop in grazing pressure.

The subsequent drop in Gramineae could be a result of greater tree cover as the values of arboreal pollen are at their highest immediately after the fall in the grasses. As mentioned previously the regeneration of trees will benefit from a drop in grazing. Alternatively, changes in local reedswamps could lead to such a change; the increase in Cyperaceae seen in this zone could be related to this.

The most straightforward explanation for the sudden peaks in *Alnus* seen in this zone is that portions of *Alnus* catkins happened to be included in the sediment sample processed for pollen analysis. Plant remains are common in this stratigraphic section. Tinsley and Smith (1974) noted that the *Alnus* catkin can break up in high winds, and hence large numbers of *Alnus* pollen grains could be transported together.

The top few centimetres of the diagram are of note. These are associated with samples taken from leaf litter resting on top of the lake muds. If one ignores the samples dominated by *Alnus* pollen, all the zonation programs (see Fig. 5.7) show the split between these three samples and the rest of the zone to be the most important within this assemblage zone. The major changes are an increase in Gramineae and a fall in *Alnus*. However, rather than representing an actual change in vegetation, these are probably due to changes in pollen recruitment processes associated with the change of sediment type, with the more immediately local vegetation being more strongly represented. The fact that the only records of *Impatiens* are from this portion of the zone could reflect this. *I.glandulifera* is found at the pondside today.

5.3 Summary

The two most important features of the pollen assemblages from this site are that a wide range of vegetation types appears to be represented and that the changes seen in the vegetation over time tend to be gradual. Woodland, including areas of coppice and wood pasture, heathland, arable agriculture and alder carr are all represented during at least one assemblage zone in the diagram. This number of habitats would be expected if, as seems the case, the pollen catchment area for this pond is relatively large due to the influence of the stream-borne pollen input.

As mentioned previously, the information given by ^{14}C dating suggests that the most probable date for the original construction of the pond is the 16th Century. If, as therefore seems likely, the pond was built in conjunction with the iron industry, the sediments should contain a record of the effects of this industry on the local vegetation. Historical documentary sources provide very little infomation on this site. However, it is possible that this iron hammer worked in conjunction with the forge at Harting Combe, Rogate (Yates, 1972 - see chapter 7). There is no evidence from the pollen record that any area of woodland in the catchment area of this site, has been cleared since the construction of pond. If anything the area of woodland has increased. There is evidence for at least part of the woodland being managed as coppice. This is reasonable, since some of the local area was probably managed to provide a renewable fuel source. It is known that the main fuel of the iron industry was underwood. in the form of charcoal (Rackham, 1986). The two major factors influencing the siting of the iron industry in the Wealden area was a local supply of iron ore and a local supply of fuel. Because of the difficulty in transporting charcoal, and in order to protect their own supplies, ironworks often owned the woods that supplied their fuel. The need for such a local supply of fuel suggests that it was on the local areas of the Lower Greensand that the areas of coppice could have been located. The decline in the importance of coppicing, suggested by the fall in *Corylus* and increase in *Quercus* and other arboreal pollen types, is almost certainly a reflection of the decline in the iron industry. This cessation of the work of the hammer would naturally cause a drop in the demand for underwood.

There is evidence for an area of heathland in zone HP1A but this area quickly seems to decline in HP1B. The loss of the heathland appears to be earlier than that seen at Burton Mill Pond. It is possible that the loss of the heathland was also due to the activity of the ironworks, *Betula* was a popular source of charcoal to fuel the industry (Straker 1931). If the heathland was close to Hammer Pond, the invasion of this tree could have been actively encouraged.

If it is assumed that much of the area close to the pond was involved in fuel production for the iron works, then the wood pasture represented in the assemblage is likely to be present further afield in the catchment on the Weald Clay. The heavier soils of this outcrop are not ideal for practices such as arable agriculture, so this would seem a logical land use. It cannot be assumed, of course, that wood pasture was confined to this area just as it cannot be assumed that coppice management was confined to the Lower Greensand near Hammer Pond. However, there is a fall in importance of wood pasture indicators through HP1B, just as coppice management declines. While the decline in coppice could be linked to the demise of the ironworks, the change in importance of wood pasture appears more difficult to explain. The increase in arboreal pollen suggests a drop in grazing pressure, allowing trees to regenerate more freely. The two most likely causes of such a change are a decline in the importance of pastoralism in the area, or the enclosure of areas of wood pasture with the exclusion of animals. Such changes could be linked with a decline in the rural population and a move towards towns seen since the advent of the industrial revolution.

CHAPTER 6- BLACK MOSS

6.1 Site Description.

Black Down is a hill (grid reference SU 920 293), around 280 metres high, on the Hythe Beds of the Lower Greensand (Fig. 6.1 gives a geological sketch map of the area). Situated about 4 kilometres south of Haslemere, much of the site is owned by the National Trust. The core studied here was taken from a shallow peat deposit located ina clearing of the coniferous woodland that covers most of this site. The vegetation of the clearing itself comprised almost total cover of *Calluna vulgaris*. A sketch map of the site showing the position the core was taken, is given in Fig. 6.2.

6.2 Core Description and Results.

6.2.1 Stratigraphy.

16cm-27cm Peat.

6.2.2 Pollen Stratigraphy.

This core was contiguously sampled every 0.5cm. At least 500 pollen grains and spores were counted from every sample. All the results in both the summary and main pollen diagrams (Figs. 6.3 and 6.4) are expressed as percentages of the total sum of pollen and spores (T.P.).

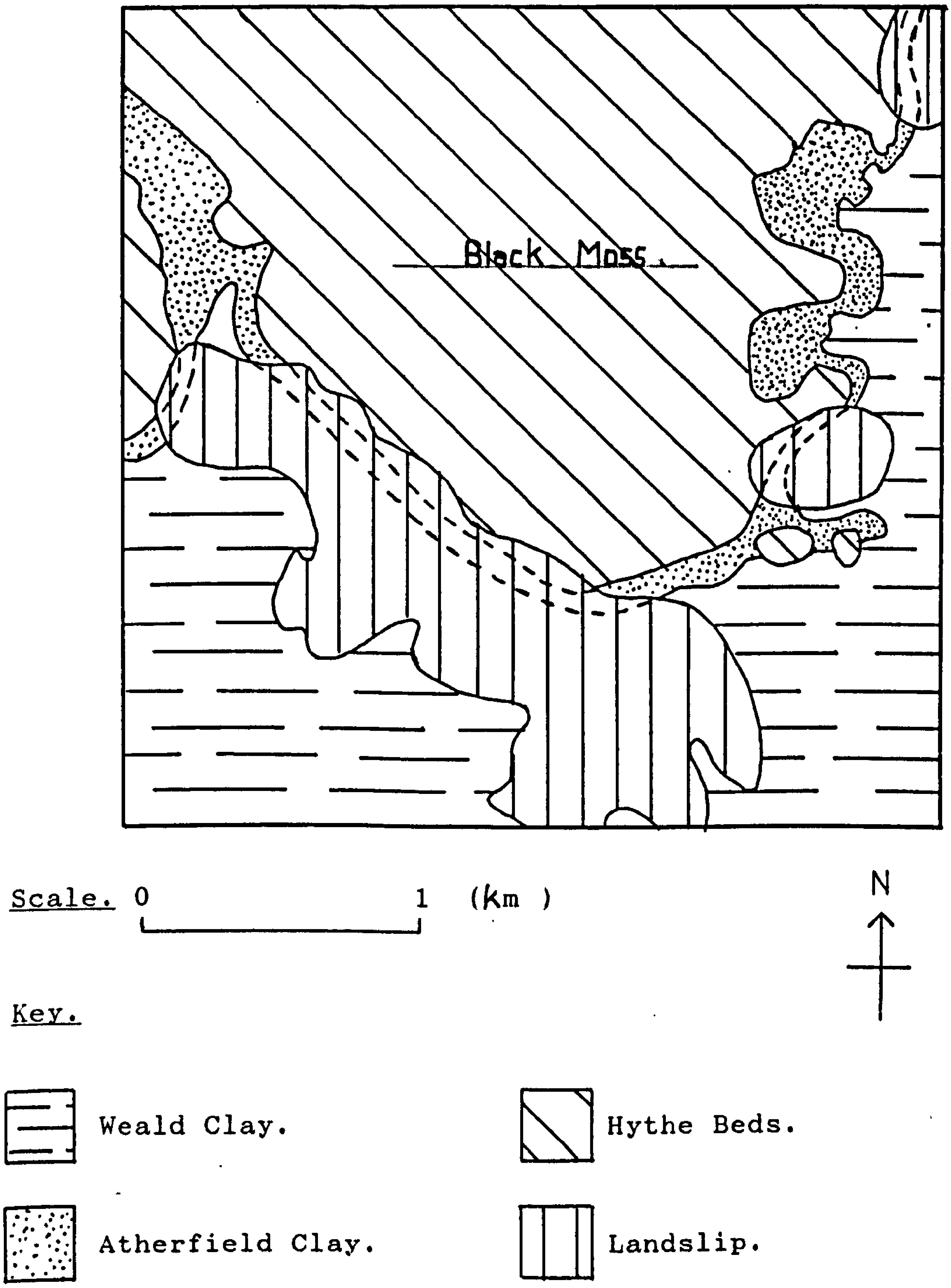
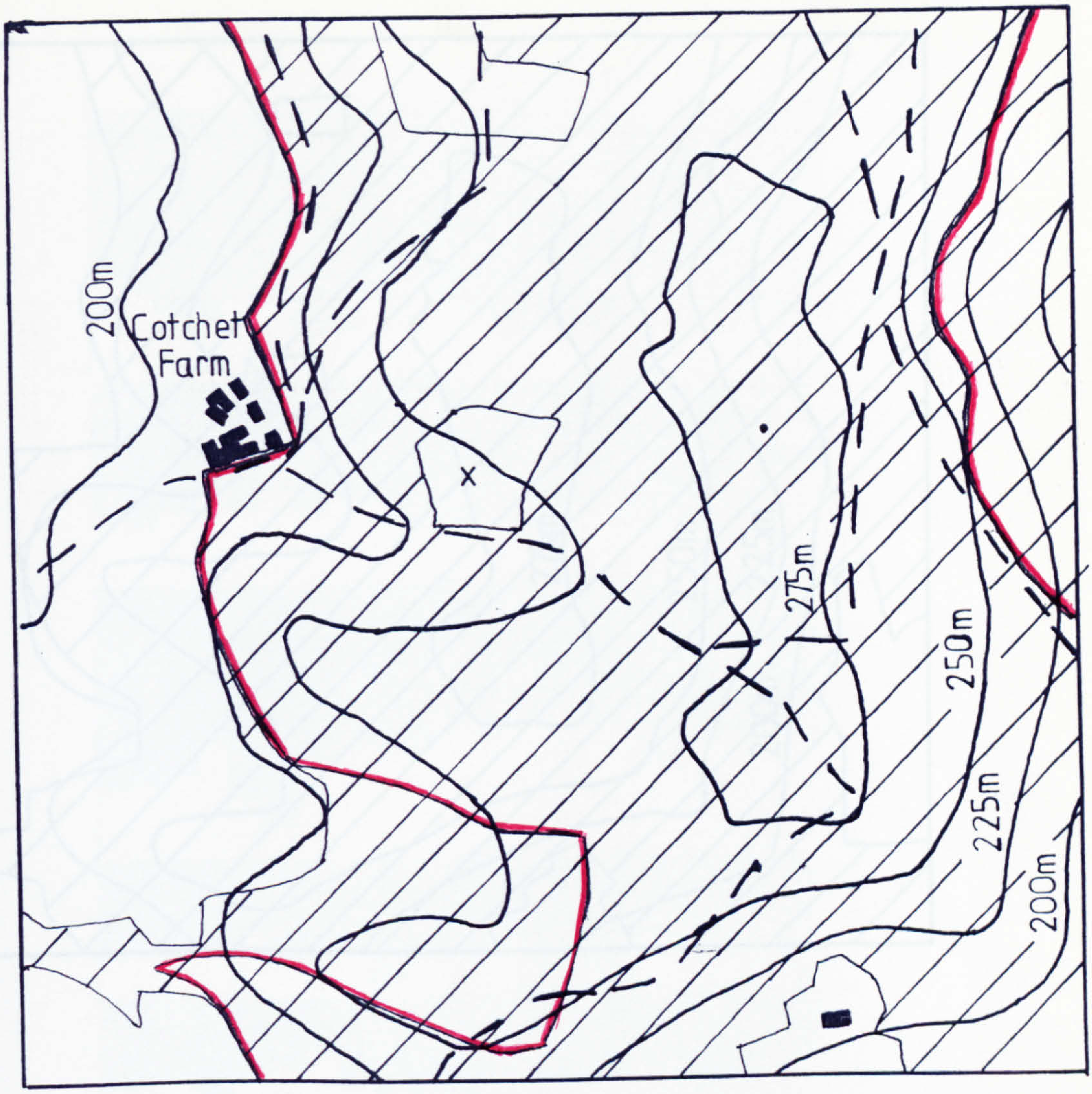


Fig. 6.1 Black Moss - Geological Sketch Map.



Scale 0 0.5 (km)

N

Key.

Wooded area.

Public Footpaths.

X Position core taken

Limit of area owned by N.T.

Fig. 6.2 Black Moss - Map of Site.

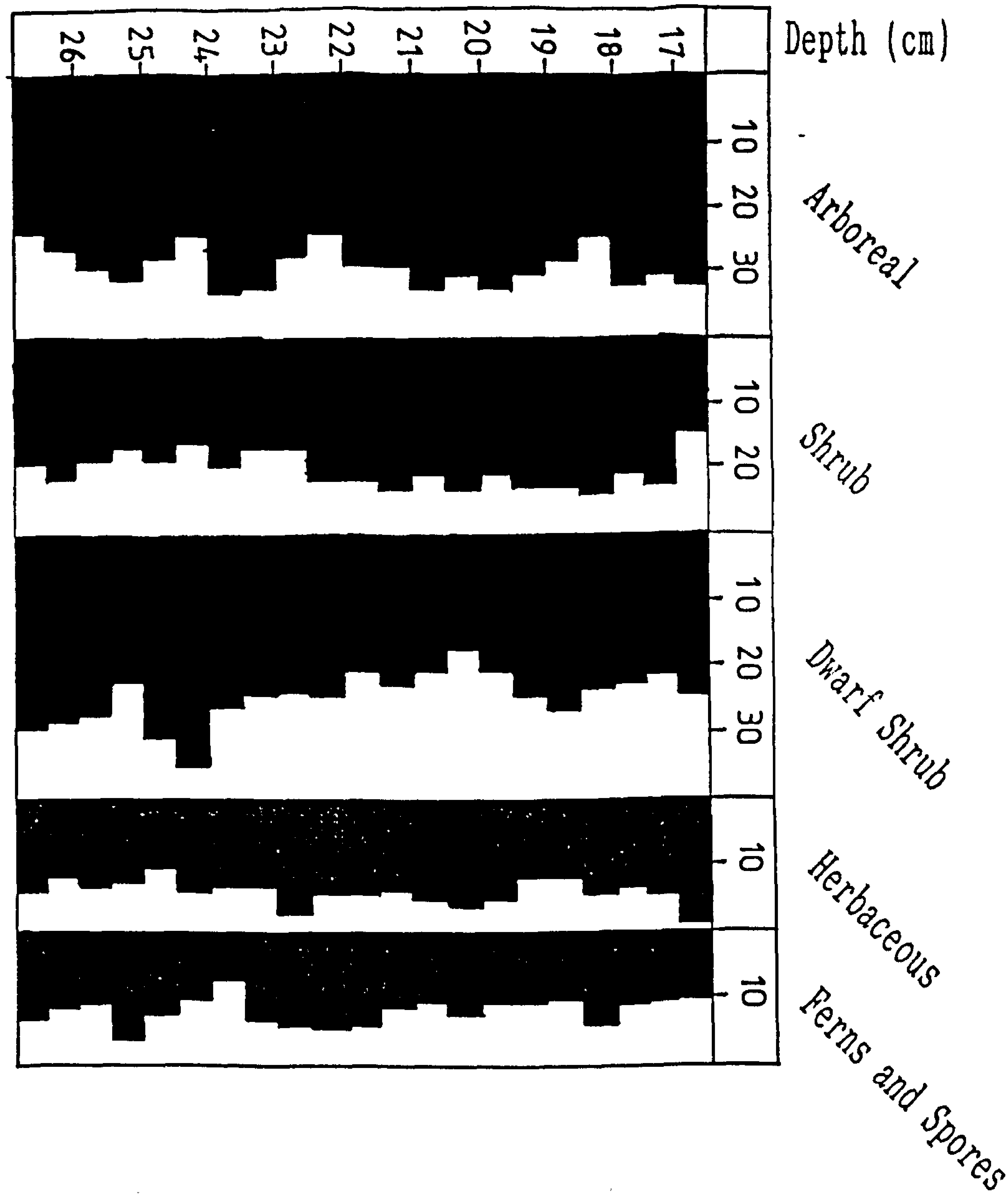


Fig. 6.3 - BM1 Summary Pollen Diagram.

(Values expressed as percentage of sum of total pollen and spores.)

Fig. 6.4 BM1- Main Pollen Diagram
All values expressed as percentages of the sum of total pollen and spores.(+ represents values <1%)

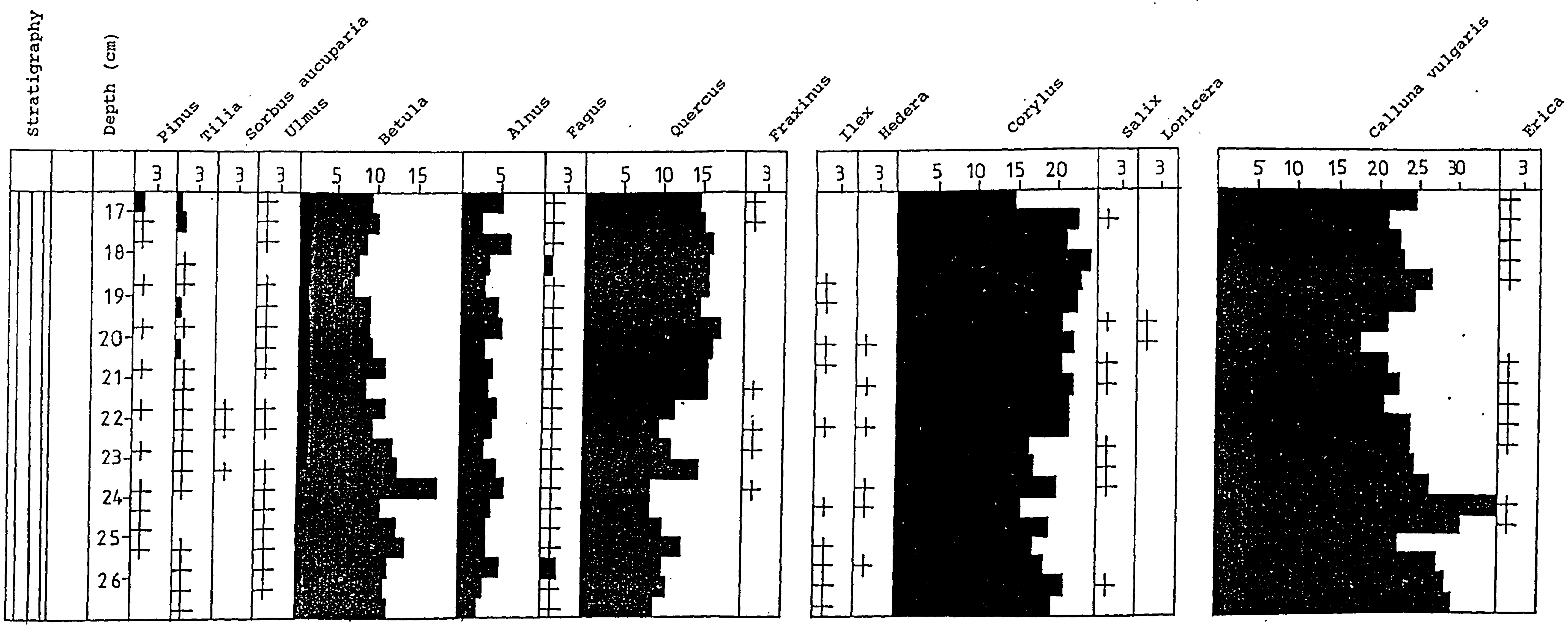
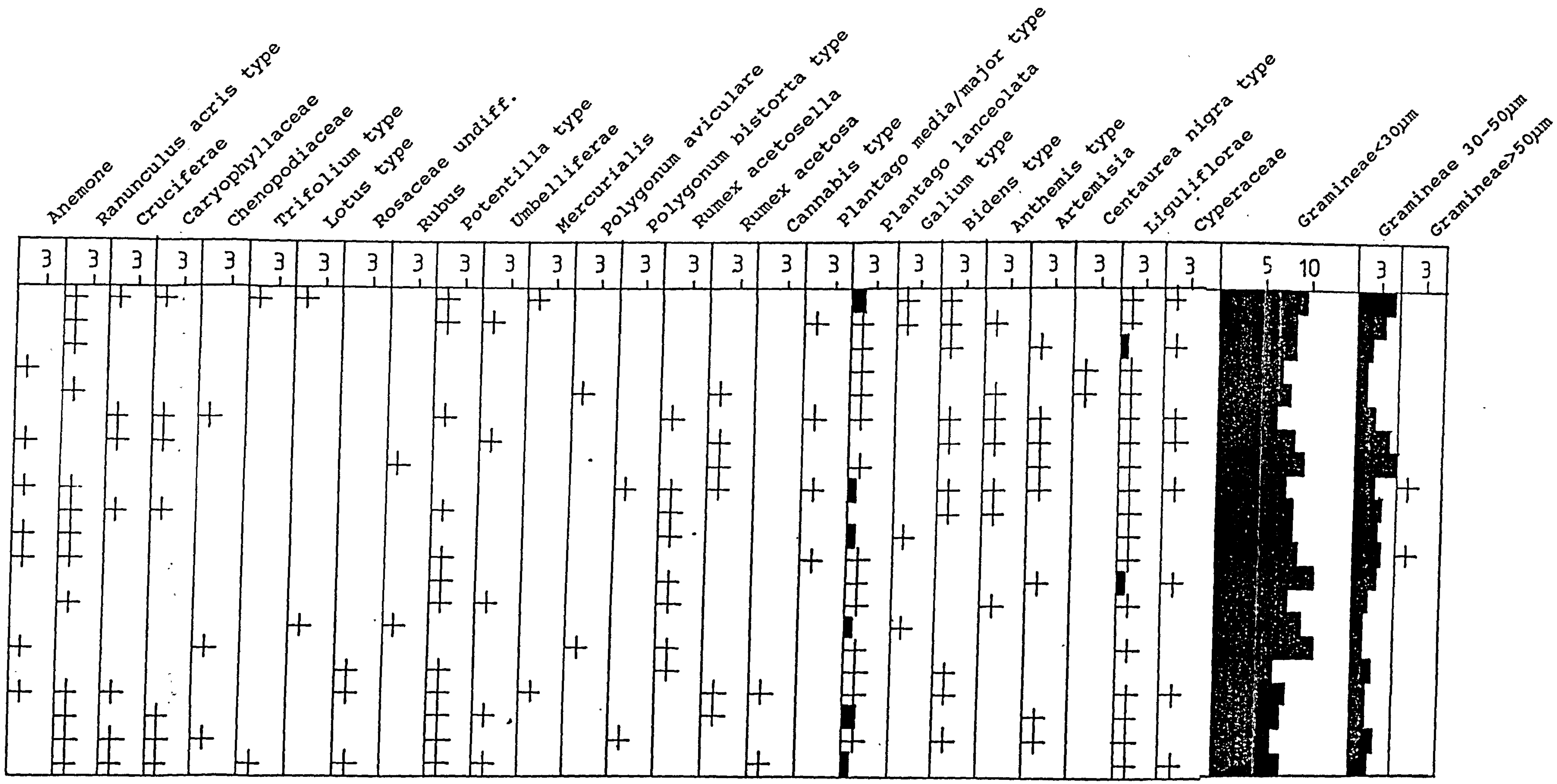


Fig. 6.4 Cont.



Anemone
Ranunculus acris type
Cruciferae
Caryophyllaceae
Chenopodiaceae
Trifolium type
Lotus type
Rosaceae undiff.
Rubus
Potentilla type
Umbelliferae
Mercurialis
Polygonum aviculare
Polygonum bistorta type
Rumex acetosella
Rumex acetosa
Cannabis type
Plantago media/major type
Plantago lanceolata
Galium type
Bidens type
Anthemis type
Artemisia
Centaurea nigra type
Liguliflorae
Cyperaceae
Gramineae<30μm
Gramineae 30-50μm
Gramineae>50μm
3
5
10

Fig. 6.4 Cont.

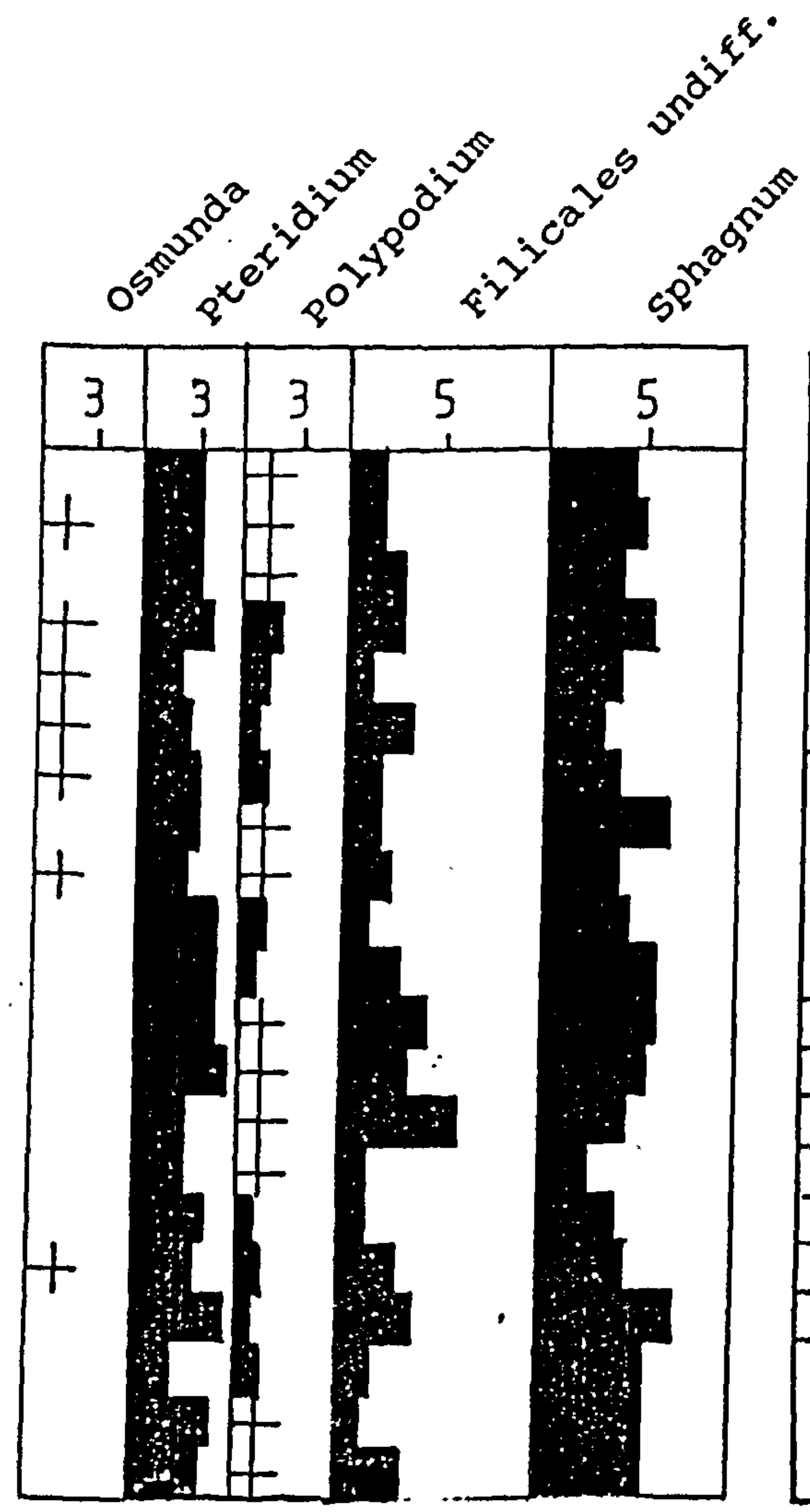
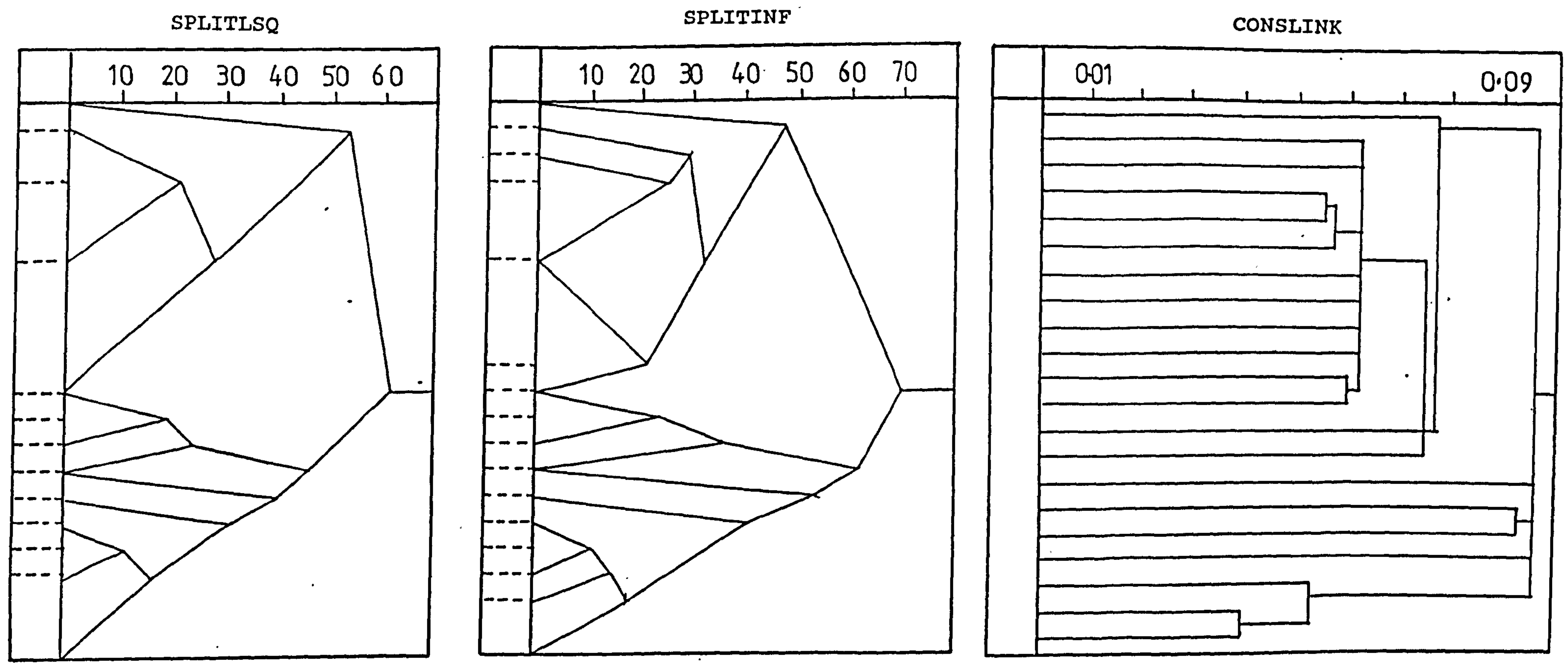


Fig. 6.6 BM1 Results of the Zonation program.



The taxa recorded that are not included in the main pollen diagram are given in Table 6.1.

6.2.3 Numerical Analysis.

The following taxa were used in the numerical programs:
Betula, *Alnus*, *Fagus*, *Quercus*, *Corylus*, *Calluna*, Gramineae, *Pteridium*, Filicales and *Sphagnum*.
The results are given in Figs 6.5 and 6.6.

6.2.4 Local Pollen Assemblage Zone Description (BM1A).

The DECORANA plot for this core shows the samples forming a single, close cluster with a maximum spread of only 0.3 standard deviations over axis 1. The zonation programs show many significant splits between samples, but this is explained as being an artefact of the program's algorithm, rather than real differences in the pollen assemblage. Therefore it was decided to treat it as a single pollen assemblage zone.

Calluna is numerically the most important pollen taxon. Apart from a peak of 35% T.P., its values are relatively stable, averaging 25% T.P.. *Corylus* is also numerous, it is slightly more frequent in the upper lower samples, but this difference is small. Overall *Corylus* averages 20% T.P..

Quercus is the commonest arboreal pollen taxon; a slight increase in the top portion of the diagram can be

DEPTH (cm)	POLLEN TYPE
17-17.5	*Sanguisorba minor, Stachys* type
18.5-19	*Carpinus, Vaccinium*
19-19.5	*Acer*
20.5-21	*Vicia sylvatica* type, *Jasione*
21-21.5	*Sambucus nigrum*
22-22.5	*Rumex obtusifolius*
22.5-23	*Solanum nigrum*
24-24.5	*Fagopyrum* type
26-26.5	*Melampyrum*
26.5-27	*Ranunculus trichophyllus*

Table 6.1 Pollen types found in the Black Moss core not included in the main pollen diagram.

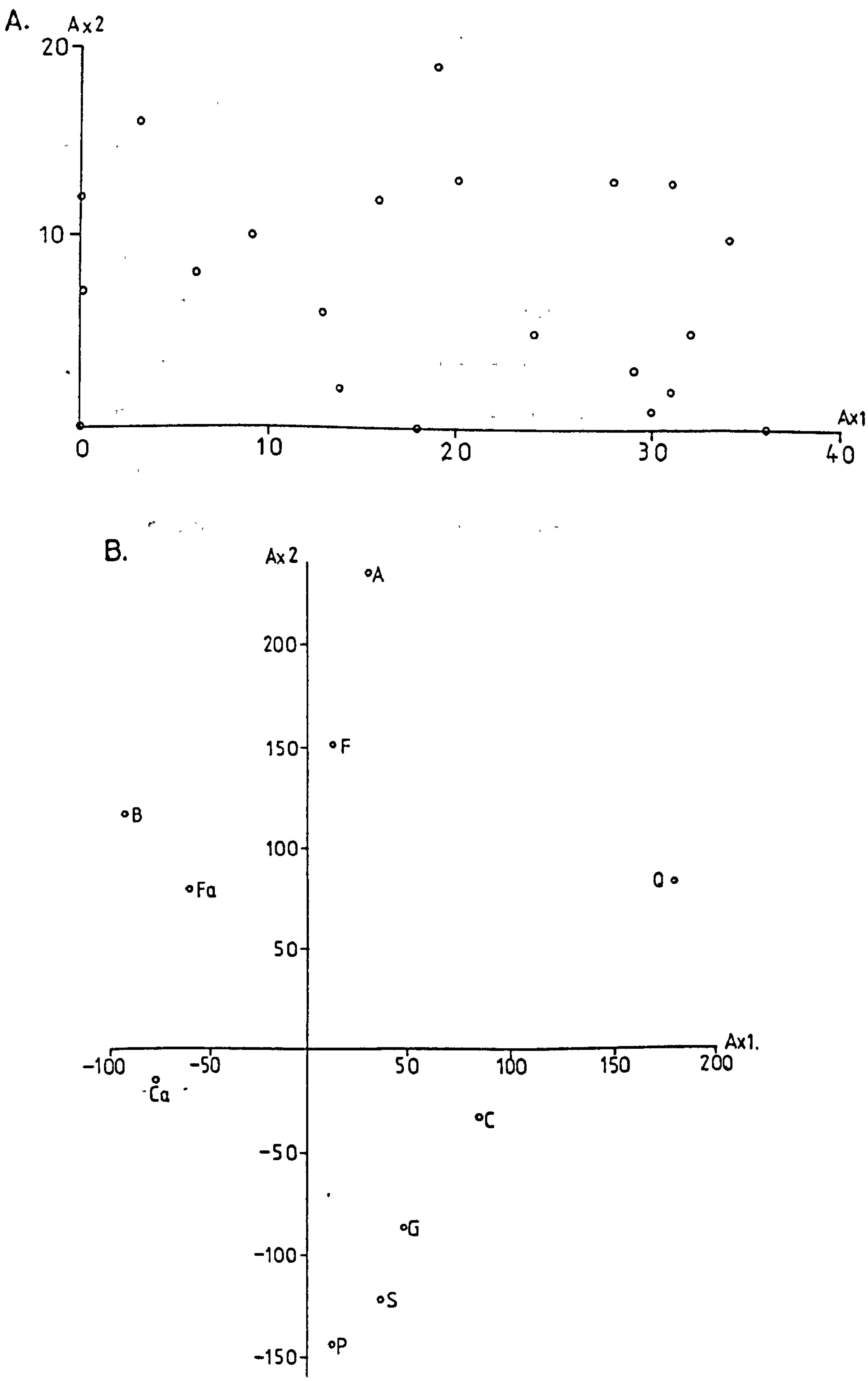


Fig. 6.5 BM1-DECORANA A-Samples B-Species

(Key overleaf)

Fig. 6.5 (cont.)

Key.

A: Samples.

o Assemblage zone BM1A

B: Species.

B - Betula

A - Alnus

Fa- Fagus

Q - Quercus

C - Corylus

Ca- Calluna

G - Gramineae

Pt- Pteridium

F - Filicales

S - Sphagnum

identified, from an average of around 10% T.P. in samples 11 to 21, to an average of 15.5% T.P. in samples 10 to 1. Apart from a peak of 17.5% T.P., the amounts of *Betula* fall slightly from values generally a little above 10% T.P. in the lower half to values generally below 10% T.P. in the upper half. *Alnus* is relatively well represented. It is stable, averaging 4% T.P.. The other arboreal taxa recorded are only found in ammounts of 1% T.P. or below.

Apart from Gramineae, the values of which change little, averaging 11% T.P., the amounts of herbaceous pollen types are low, with no single taxon accounting for above 1.5% T.P. in any sample.

Fern and Sphagnum spores are also stable through the diagram; *Pteridium* and Filicales both average around 3% T.P., while *Sphagnum* accounts for an average of nearly 5% T.P..

6.2.5 Local Pollen Assemblage Zone Interpretation.

The nature of this assemblage suggests that it is best interpreted as representing at least two vegetation types in relatively close proximity to the sampling site. *Calluna* is the most abundant pollen type and there is a relative abundance of herbaceous pollen types, which suggests that the sampling site itself was relatively open. The *Calluna*, together with records of *Erica, Vaccinium, Campanula* and *Rumex acetosella* pollen types, suggest that at least some areas of heath were present. However, the values of *Calluna* pollen are lower than usually obtained from open heath, suggesting that there was an incomplete cover of this species in the immediate area of the sampling site (Evans and Moore, 1985). It is possible that *Pterdium* (often poorly represented in pollen diagrams) and grasses were co-dominant in the immediate area. The relative importance of *Sphagnum* spores suggests that there are some areas wet enough to support the growth of these mosses in the near vicinity.

The fact that locally open conditions are present is supported by the combined amounts of the arboreal pollen types being below the value of 51% T.P., suggested by Tinsley and Smith (1974), to be a good indicator of woodland conditions. It is probable that some woodland was close to sampling site. The arboreal pollen totals are above those that might be expected from open heathland, and are possibly due to an edge-effect exerted on the pollen deposition by nearby woodland. Tinsley and Smith (1974) suggested that such an edge-effect is not likely to extend over 100m. The frequent records of *Ilex* and *Hedera* pollen (both poorly dispersed pollen types) and *Polypodium* spores, add evidence to the proximity of woodland.

The arboreal pollen assemblage indicates that *Quercus* is almost certainly the dominant tree in the area, with *Betula* also being important, possible in gaps in the *Quercus* canopy or around the woodland edges. The values of *Alnus*, a tree whose pollen production is similar to that of *Quercus* and *Betula* (Andersen, 1970; Bradshaw, 1981) are significantly lower. This might be expected as conditions on the top of Black Moss are unlikely to be favourable for this tree, and the pollen has probably, therefore, been transported from trees growing in locations such as at the nearby springline at the bottom of the junction of the Hythe Beds and Atherfield Clay (see Fig. 6.1) or from streamsides on the Weald Clay.

The practically continuous records of the poorly represented arboreal pollen types, *Tilia, Ulmus* and *Fagus* shows their presence but it is impossible to judge if these grains are derived from close to the sampling site or are a more regional component.

The importance of *Corylus* in the assemblage suggests that it could be of more local significance. The amounts of its pollen clearly indicate it is able to flower well, and therefore must be growing away from canopy cover. It is possible that the pollen is derived from either areas of *Corylus* coppice, *Corylus* growing at the edge of woodland or from locally growing shrubs. The fact that amounts of dwarf shrubs, herbs and grass pollen are lower than might be expected from open heath supports the hypothesis that the area local to the sampling site could be a mixture of heath and *Corylus* scrub.

The apparently open conditions in the area of the sampling site are probably maintained by grazing preventing the establishment of tree seedlings. The records of *Rumex acetosa* and *Potentilla* pollen are a possible indication of this. Although *Plantago lanceolata* is the the commonest herbaceous pollen type after

Gramineae, it is only present in relatively low numbers, suggesting that this species is not growing locally, but the pollen is derived from areas of pastoral activity some distance from the site. However the record of *Fagopyrum*, a pollen type not well dispersed, suggests the possibility of arable farming taking place near to the site. There are also records of possible cereal pollen and of *Polygonum aviculare* pollen (a species that can be a weed of arable land) which supports this hypothesis.

6.3 Discussion.

In the absence of ^{14}C dated from this core it is difficult to establish the chronology of this site. The absence of high amounts of pollen from coniferous trees such as *Pinus* show that the peat must pre-date the establishment of the current vegetation at the site. This suggests that either peat growth ceased at the site a significant time ago, or that material has been removed through peat cutting or possibly erosion. *Pinus* pollen is found throughout the core but only in very low numbers, which shows that, although this species was not growing close to the site, it is possible that the tree was established in the region. However, when one considers that *Pinus* pollen is often transported over very long distances (Ritchie and Lichti-Federovich, 1967), and that this site is situated on a relatively high hill for the area, which could receive pollen transported over long distances, it is possible that these records represent pollen grains derived from distant sources.

The importance of heathland taxa in the assemblage indicate that it is unlikely that the peat dates from earlier than the Bronze Age. However, it could of course be far more recent. The vegetation represented by this pollen assemblage, possibly a mixture of heathland and *Corylus* scrub, however, is rather similar to that seen in the valley mire core from Burton Mill Pond (BMP3), just after the clearance episode seen in that diagram.

Although it is known that within living memory the site carried open heath (E.M. Yates, pers. com.),
the major conclusion from this site, however, is still that the Hythe Beds of the Lower Greensand formerly carried heathland to a greater extent than it does now. The mixed nature of the pollen assemblage, and its similarity to Burton Mill Pond assemblage mentioned previosly, suggest that it possibly represents a stage in the early development of the heath.

CHAPTER 7- COMBE POND.

7.1 Site Description.

This site is a small artificial lake, Grid Reference SU 814 269, about 3km North East of the village of Rogate, West Sussex. The pond is situated in the area known as Harting Combe, which lies on the most westerly point of the Weald Clay outcrop. Fig. 7.1 gives a geological sketch map of the area.

The present-day vegetation around the pond is a mixture of farmland, woodland and more open scrub. Fig. 7.2 gives a sketch map of the area, and shows the extent of the local tree cover.

7.2 Core Description and Results.

7.2.1 Stratigraphy.

0.0- 4.0cm Leaf litter.

4.0- 41.0cm Water gap.

41.0- 50.0cm Lake mud with abundant humified plant remains.

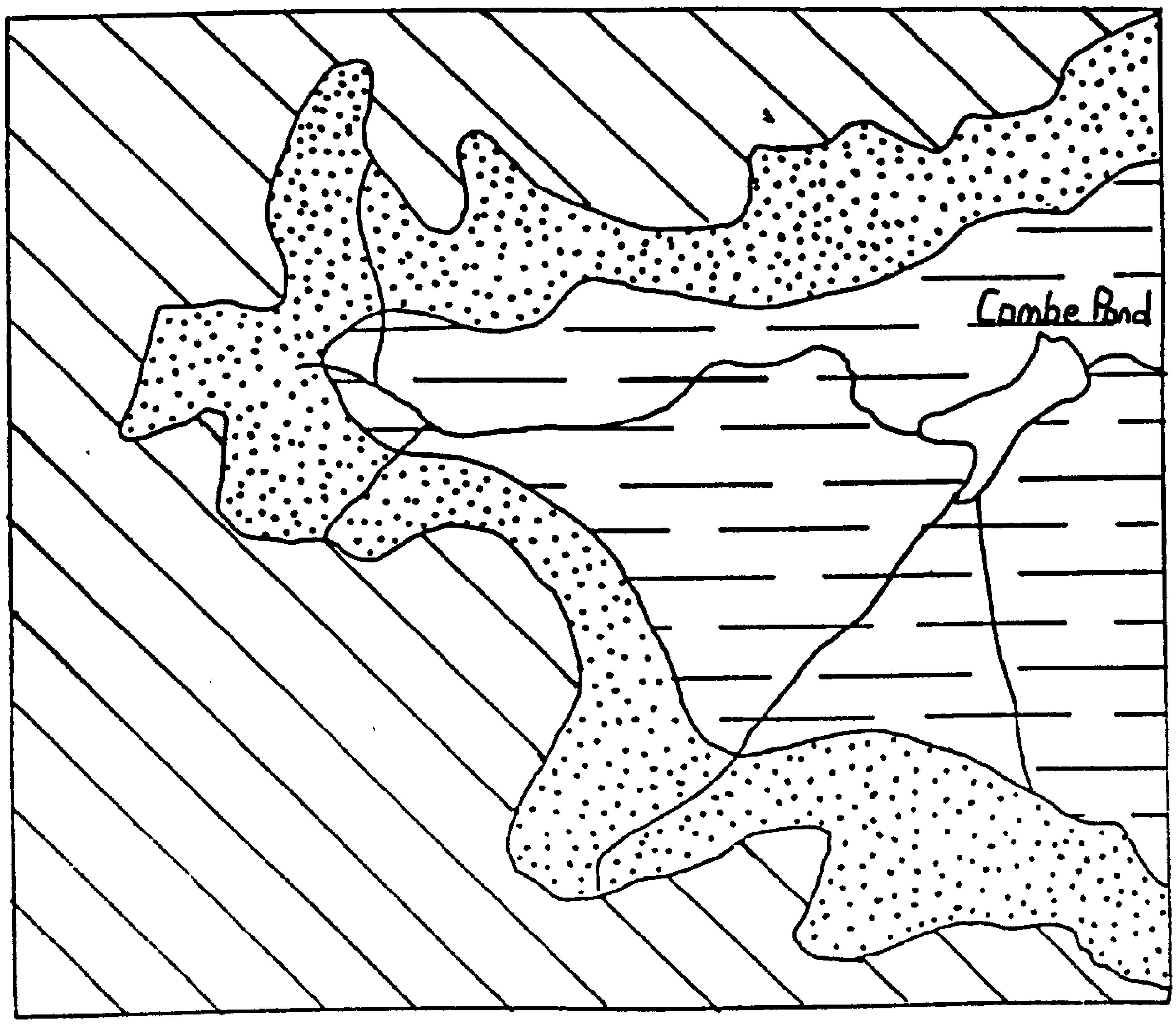
50.0- 53.0cm Water gap.

53.0- 80.0cm Lake mud with abundant humified plant remains.

80.0-137.5cm Clay.

137.5-139.5cm Dark organic band.

139.5-167.0cm Clay.



Scale 0 1 (km)

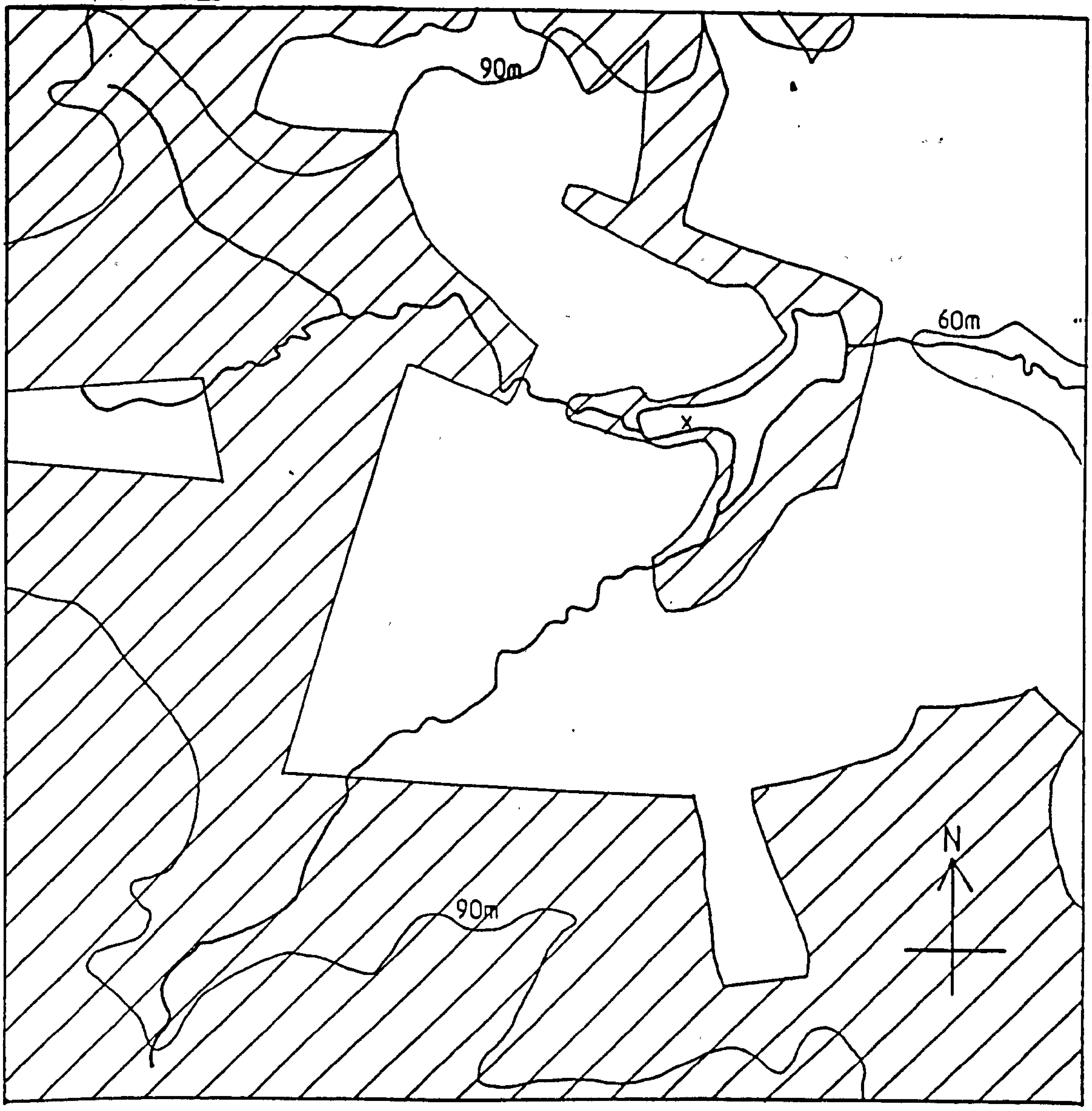
Key.

Weald Clay.

Atherfield Clay.

Hythe Beds.

Fig. 7.1 Combe Pond - geological sketch map.



Scale 0 1 (km)

KEY.

- Wooded area

x - position core taken.

Fig. 7.2 Combe Pond - Map of site.

7.2.2 Pollen Stratigraphy.

This core was sub-sampled every 4cm. At least 500 pollen grains and spores were counted from each sub-sample. The summary and main pollen diagrams (Figs. 7.3 and 7.4) were both constructed using the results expressed as percentages of total pollen and spores (T.P.). The pollen types recorded that are not shown on the main pollen diagram are given in Table 7.1.

7.2.3 Numerical analysis.

The following taxa were used in all the computer programs: *Pinus*, *Betula*, *Alnus*, *Fagus*, *Quercus*, *Corylus*, *Calluna*, *Potentilla*, *Plantago lanceolata*, Liguliflorae, Cyperaceae, Gramineae, *Pteridium*, *Polypodium* and Filicales.

The results of these analyses are given in Figs. 7.5 and 7.6.

7.2.4 Local Pollen Assemblage Zone Descriptions.

Zone CP1A. Depth 169 - 141cm.

From the zonation programs it can be seen that the upper boundary of this zone, between samples 27 and 26, is mathematically the most important split in the diagram. However, within this zone, importance is given to the split between samples 29 and 28. This is probably due simply to the high numbers of *Corylus* and *Pteridium*

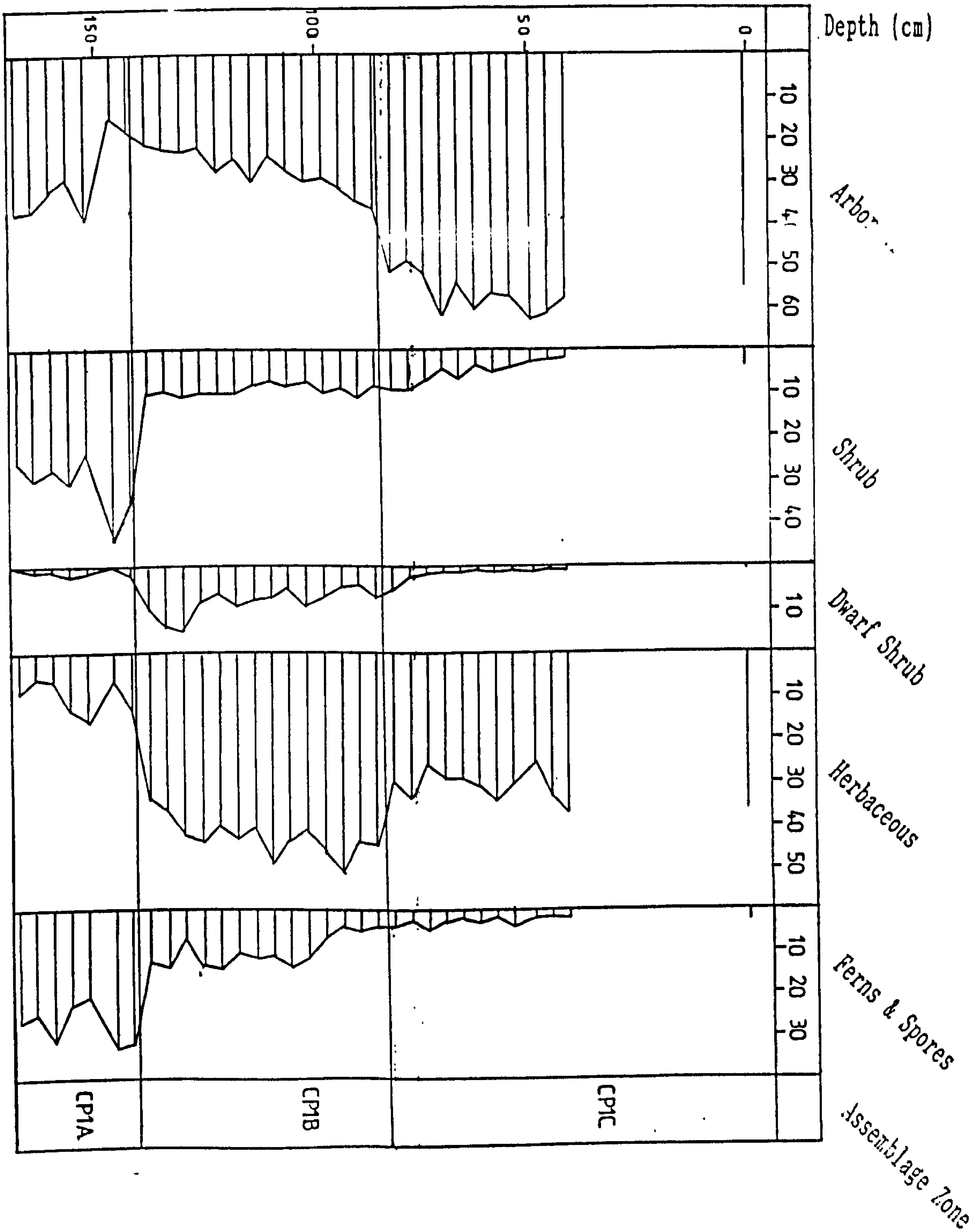


Fig. 7.3 - CP1 Summary Pollen Diagram.

(Values expressed as percentage of sum of total pollen and spores.)

Fig. 7.4 CP1- Main Pollen Diagram
All values expressed as percentages of the sum of total pollen and spores.(+ represents values <1%)

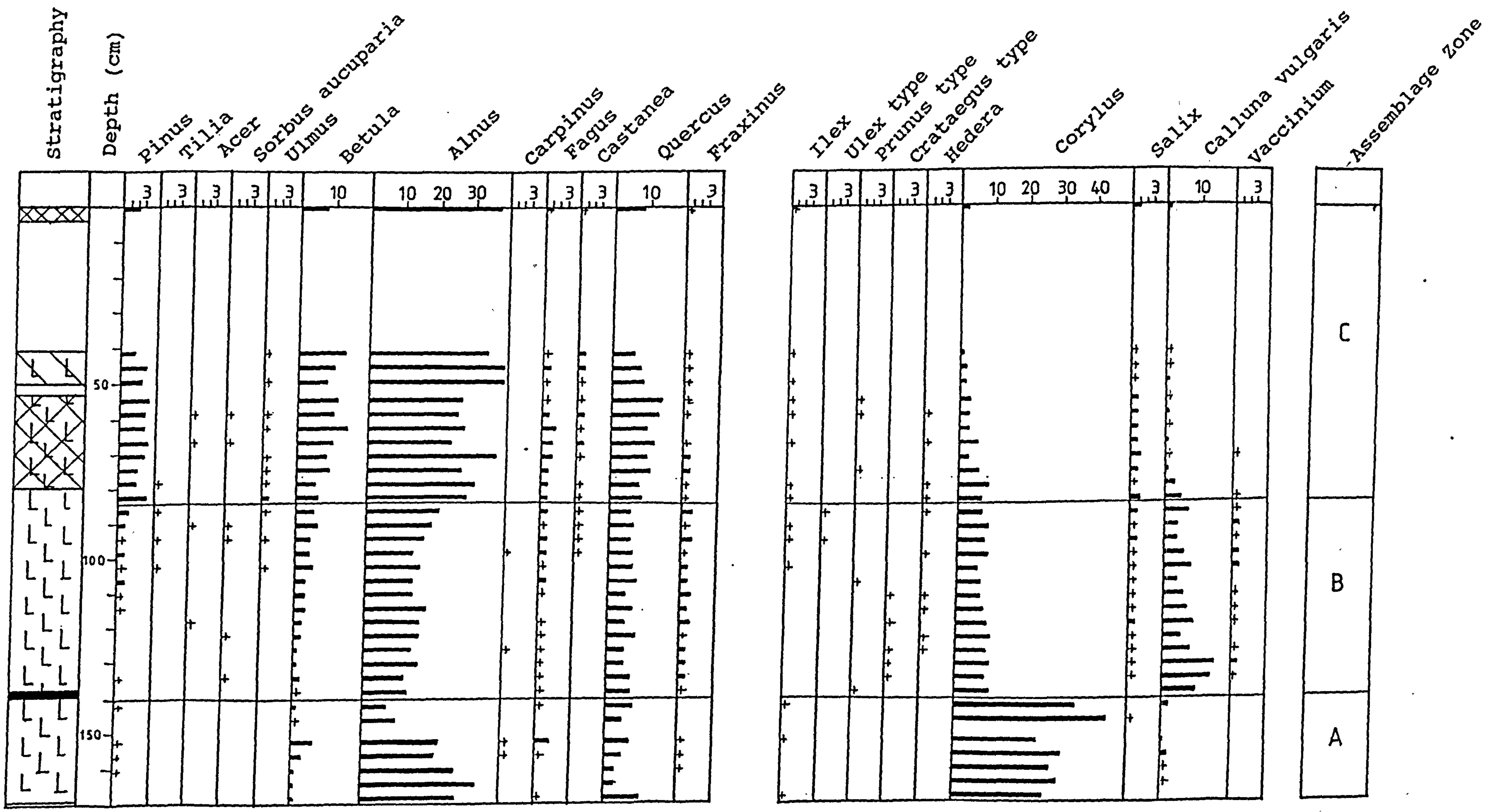
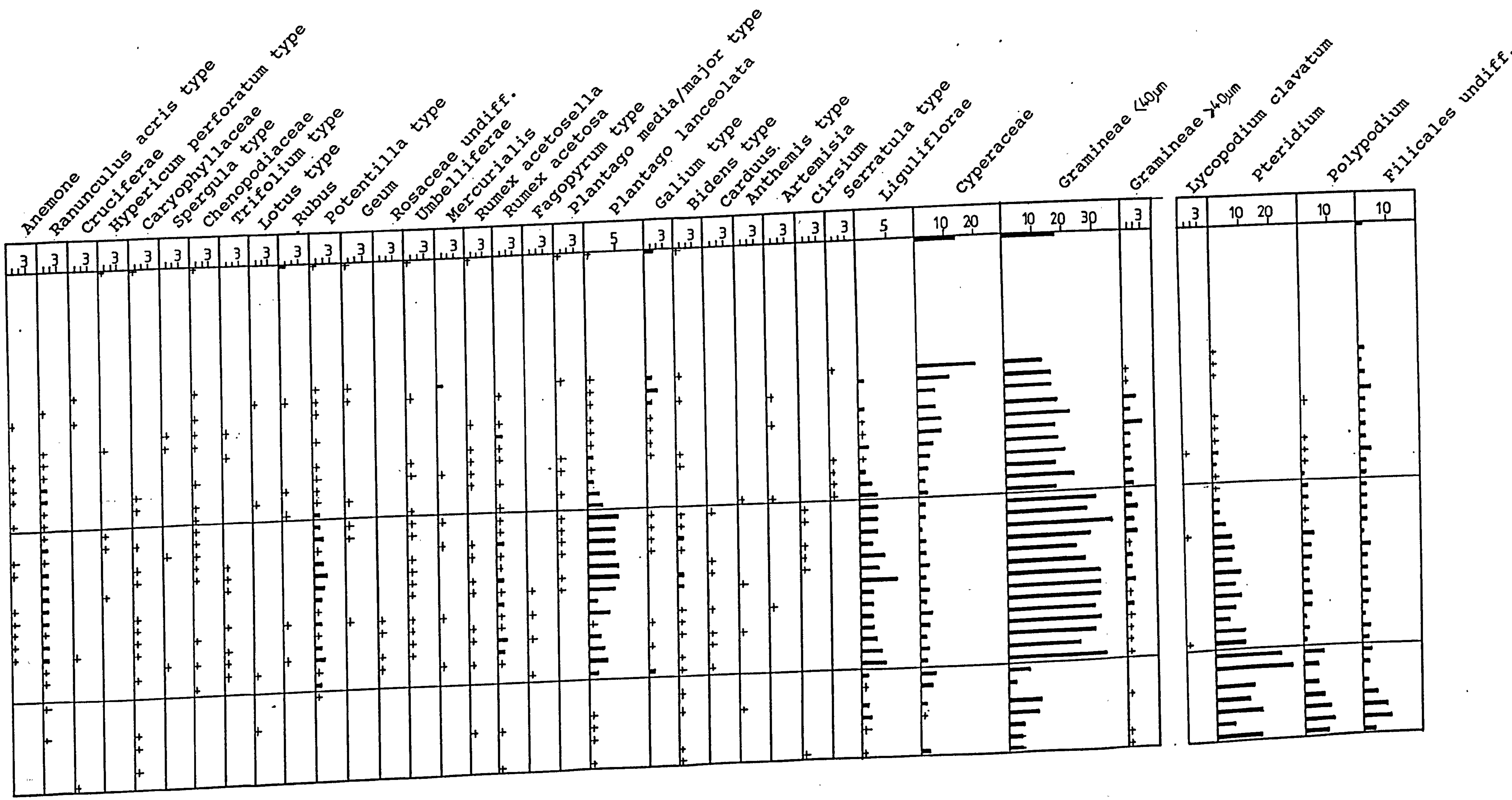


Fig. 7.4 Cont.



Anemone
Ranunculus acris type
Cruciferae
Hypericum perforatum type
Caryophyllaceae
Spergula type
Chenopodiaceae
Trifolium type
Lotus type
Rubus
Potentilla type
Geum
Rosaceae undiff.
Umbelliferae
Mercurialis
Rumex acetosella
Rumex acetosa
Fagopyrum type
Plantago media/major type
Plantago lanceolata
Galium type
Bidens type
Carduus.
Anthemis type
Artemisia
Cirsium
Serratula type
Liguliflorae
Cyperaceae
Gramineae <40μm
Gramineae >40μm
Lycopodium clavatum
Pteridium
Polypodium
Filicales undiff.

Fig. 7.4 Cont.

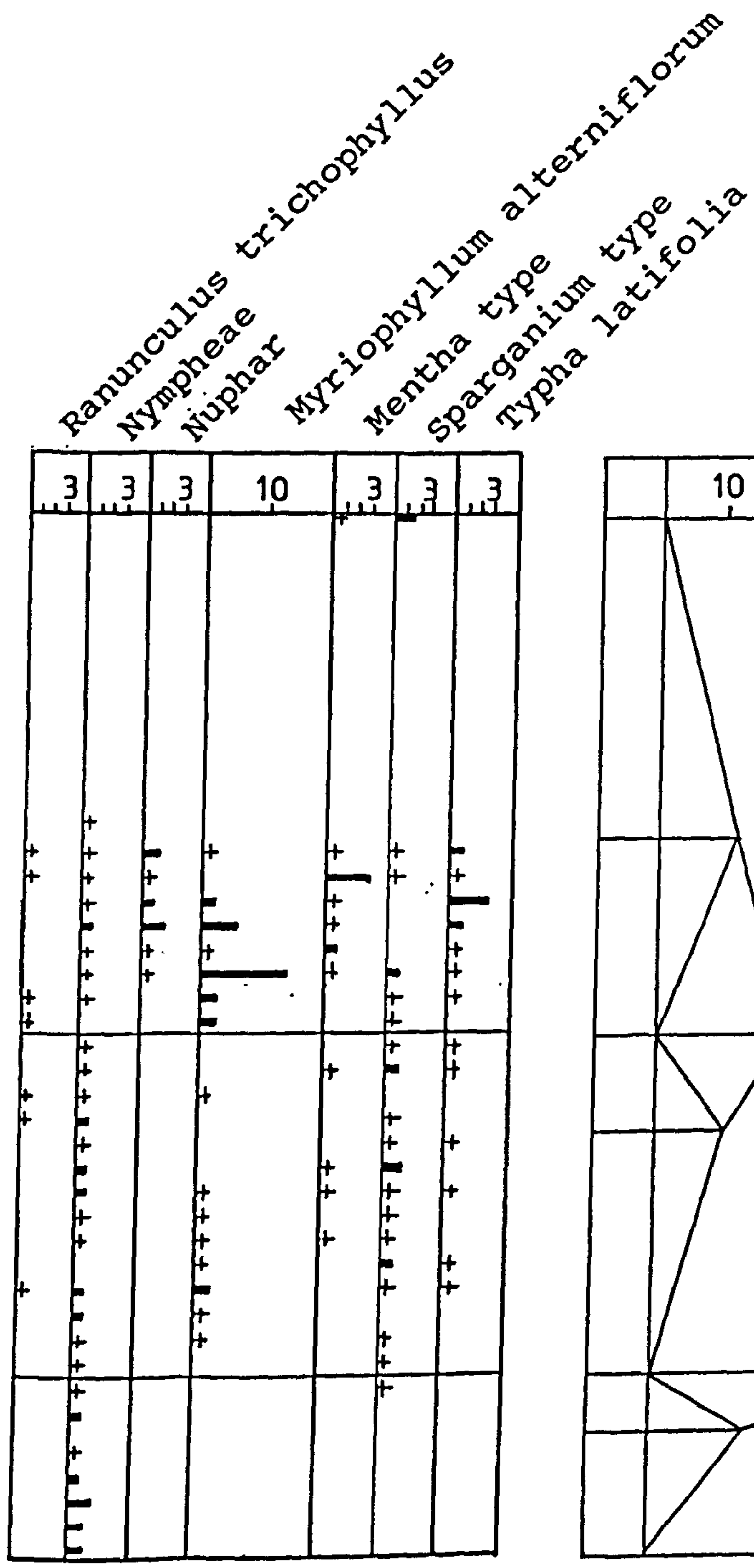
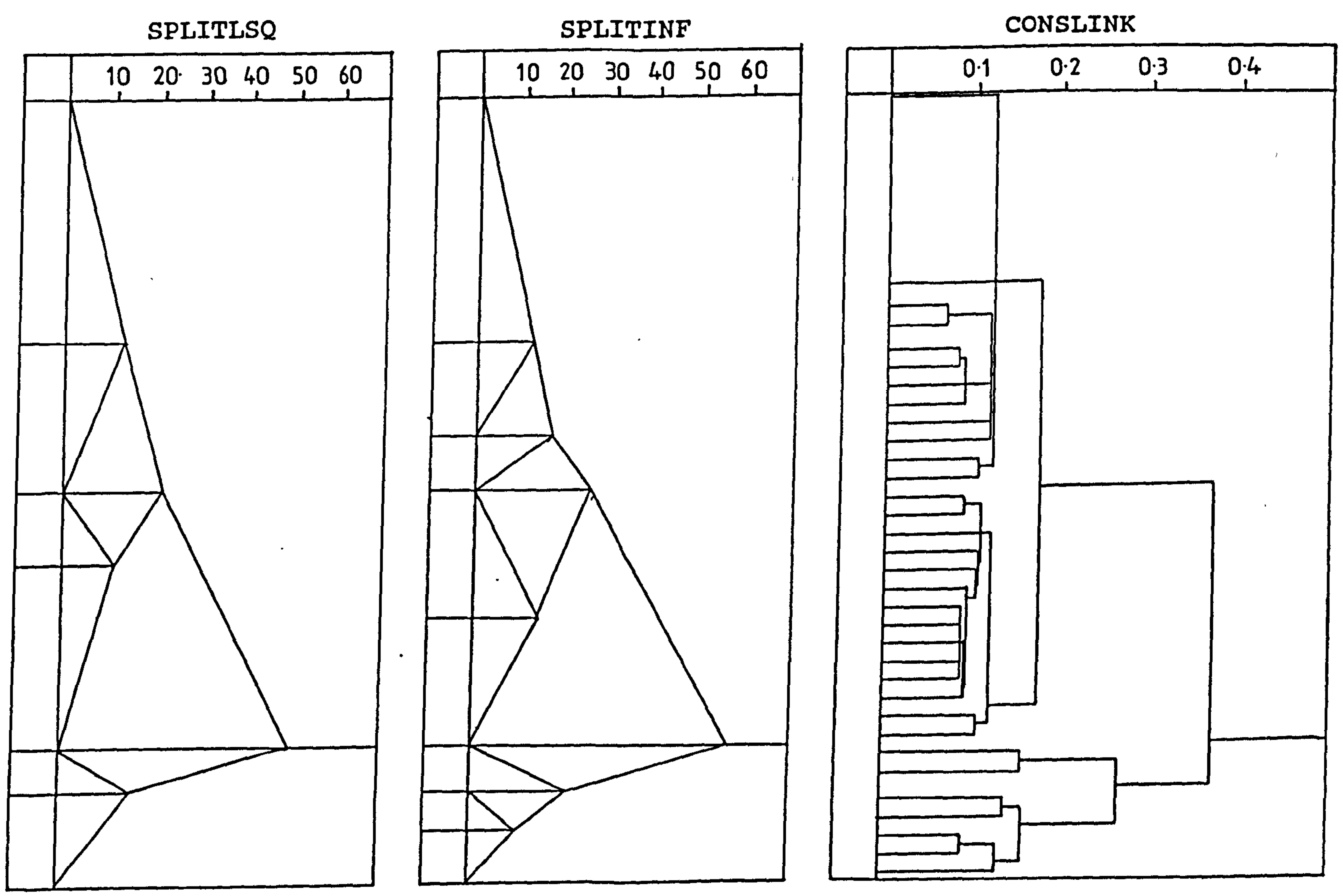


Fig. 7.6 CP1 Results of the Zonation program.



DEPTH (cm)	POLLEN TYPE
45-46	*Filipendula, Polygonum persicaria* type, *Rumex obtusifolius*
54-55	*Filipendula, Rumex obtusifolius, Rhinanthus* type
58-59	*Ligustrum, Lysimachia* type
66-67	*Sambucus nigra, Sinapis* type, *Urtica*
70-71	*Allium* type
78-79	*Ononis* type, *Polygonium persicaria* type, *Cannabis* type, *Solanum dulcamara, Centaurea nigra* type
86-87	*Ononis* type, *Epilobium* type, *Solanum dulcamara*
90-91	*Ononis* type, *Solanum dulcamara, Allium* type
94-95	*Juglans, Lathyrus, Centaurea nigra* type, *Callitriche*
98-99	Boraginaceae, *Centaurea nigra* type
102-103	*Frangula, Filipendula, Rumex obtusifolius*, Scrophulariaceae type
106-107	*Polygonum bistorta* type
118-119	*Asplenium* type
130-131	*Polygonum amphibium*
134-135	*Polygonum amphibium*
138-139	*Polygonum amphibium*
152-153	*Melampyrum*

Table 7.1 Pollen types found in Combe Pond not included in the main pollen diagram.

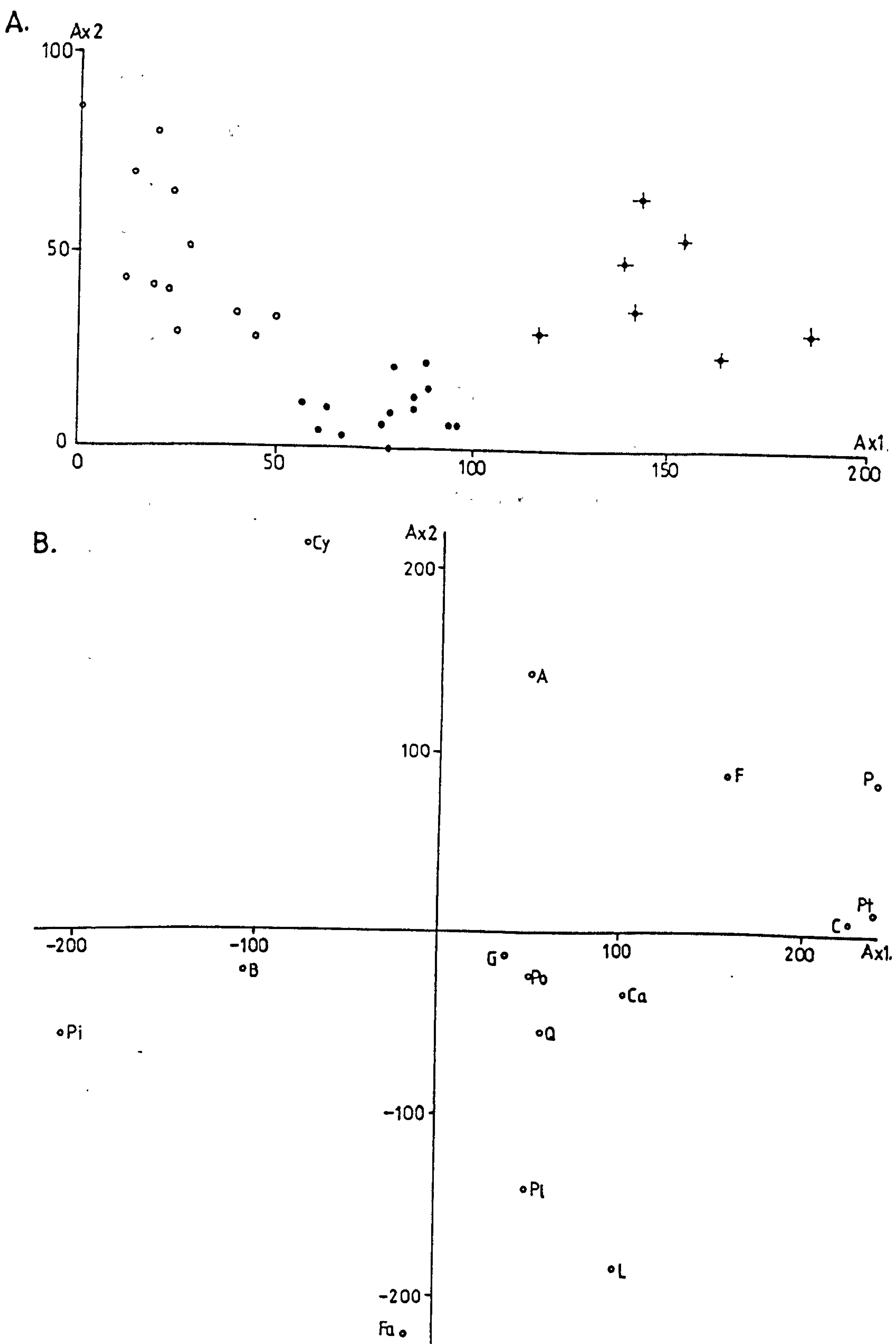


Fig. 7.5 CP1-DECORANA A-Samples B-Species

(Key overleaf)

Fig. 7.5 (cont.)

Key.

A: Samples.

- Assemblage zone CP1A
- ● Assemblage zone CP1B
- o Assemblage zone CP1C

B: Species.

Pi- Pinus	Pl- Plantago lanceolata
B - Betula	L - Liguliflorae
A - Alnus	Cy- Cyperaceae
Fa- Fagus	G - Gramineae
Q - Quercus	Pt- Pteridium
C - Corylus	P - Polypodium
Ca- Calluna	F - Filicales
Po- Potentilla	

in the upper two samples. DECORANA also shows these samples as a distinct, somewhat diffuse, cluster.

This zone is characterised by high values of *Corylus* pollen and fern spores. *Corylus* is dominant, increasing towards the top of the zone and peaking at 45% T.P.. *Pteridium* is the most numerous spore. Its values are variable, but increase towards the top of the zone. *Polypodium* and Filicales are both well represented, both being more numerous in the lower portion of the zone where they each account for about 10% T.P.. *Alnus* is the most numerous arboreal pollen type, but it falls from 37% T.P. to 7% T.P. through the zone. *Quercus* is relatively important, but it fluctuates between 4% and 11% T.P.. *Betula* peaks briefly in the centre of the zone.

The values of Gramineae and the herbaceous taxa are generally low. Gramineae peaks at around 11% T.P., but only accounts for around 5% in the other samples. Cyperaceae is relatively common in samples 27 and 28 , with values approaching 5% T.P. in each. *Nymphaea* is the only numerous aquatic pollen type present.

Zone CP1B. Depth 141 - 84cm.

The upper boundary of this zone, between samples 13 and 12, is again found to be significant by all the programs. The distinct, close grouping shown by these samples on the DECORANA plot reflects their close similarity to each other.

This zone is marked by a drop in the numbers of *Corylus* and an increase in *Calluna*, Gramineae and herbaceous taxa. *Corylus* is stable, averaging 9% T.P.. *Calluna* shows a greater degree of variation, between 4% and 15% T.P., and is slightly more numerous at the beginning of the zone. Gramineae is relatively stable, averaging 30% T.P.. There is a marked increase in both the amounts of herbaceous pollen present and also in the number of taxa represented. The most important herbaceous types are *Plantago lanceolata* and Liguliflorae which both acheive maximum values of around 5% T.P..

Alnus is again the most numerous arboreal pollen type, increasing gradually to 21% T.P. by the end of the zone. *Quercus* is stable, averaging almost 7% T.P.. *Betula* increases from less than 1% T.P. to around 5% T.P. by the end of the zone. It is noteworthy that *Pinus* first appears consistently in this zone, and that *Fagus* and *Fraxinus* are more numerous than in the previous zone, but all three of these taxa are present in levels below 2% T.P..

Pteridium, *Polypodium* and Filicales are all less important. *Pteridium* falls away to less than 1% T.P. by the end of the zone, while the values of Polypodium and Filicales are steadier, but consistently lower than 5% T.P.. There is an increase in the number of aquatic taxa represented.

Zone CP1C. Depth 84 - 0cm.

Within this zone, both SPLITINF and SPLITLSQ assign significance to the split between samples 5 and 4. However, this and the diffuse nature of the DECORANA grouping of these samples are explained by the increase in *Alnus* and to a lesser extent Cyperaceae in the upper portion of this zone.

The zone is characterised by an increase in the numbers of arboreal pollen. *Pinus* is stable at an average of 3% T.P. *Betula* fluctuates slightly between 7% and 14% T.P.. *Alnus* is present at values between 24% and 40% T.P., but is more important in the upper samples. *Quercus* is relatively stable, with a maximum value of 15% T.P.. The increase in arboreal taxa is accompanied by falls in most other taxa.

Corylus declines to 2% T.P. by the end of the zone. *Calluna* also falls through the zone, to values around 1% T.P.. Gramineae is stable, averaging around 19% T.P., while the levels of practically all other herbaceous taxa fall markedly. Cyperaceae is the only major exception to this general trend; it increases through this zone to a maximum of 20% near the top.

The numbers of some fern taxa drop, with the exception of Filicales which is practically unchanged from the previous zone. An increase is seen in values of aquatic pollen types: *Nuphar, Myriophyllum alterniflorum, Mentha* and *Typha latifolia* all show significant values in this zone.

7.2.5 Local Pollen Assemblage Zone Interpretations.

This small pond lies at the furthest point west of the Weald Clay in a small basin surrounded on three sides by the higher ground of the Lower Greensand. It is fed by two streams that rise at the spring line at the junction of the the Hythe Beds and Atherfield Clay divisions of the Lower Greensand. Therefore, the pollen catchment area of this site is likely to be relatively limited, the pollen assemblage being dominated by input from the Weald Clay area via the stream and the air. Pollen input from the nearby Lower Greensand and from further afield will be less important, being mainly derived from the air.

From the study by Yates (1972) of the historical records associated with this area, it would seem that this pond was built to be used in conjunction with ironworks at the site in about 1588. Therefore, assuming that the pond sediments have been undisturbed, it can be taken that this is the basal date for the diagram.

Zone CP1A.

The high *Corylus* values show that this species is common and able to flower readily, suggesting that the hazel is not growing under a tree canopy as *Corylus* flowers poorly and produces little pollen under shade (Andersen, 1970). The fact that an iron furnace was present at this site strongly suggests that the *Corylus* was part of a coppiced system managed for fuel production.

Evidence from historical records (Yates, 1972) can help in the interpretation of the assemblage. The ironworks associated with this pond was a large furnace.

Evidence given at a local commission of enquiry made by the Exchequer authorites in January 1589 stated that the ironworks were created on the site of a corn mill by one Francis Fortescue, and that on 25th March 1588 the works were leased to Henry Gleed of Arlington and Micheal Martin of Rogate, "with provision for finding 5,000 cords of wood each year and sufficient iron mine (ore)".
This gives information on a number of points. The word wood has important legal and practical implications (Rackham, 1980). It specifically means poles, brushwood and other small stuff rather than tree trunks which are referred to as timber. That 5,000 cords of wood could be found each year gives an indication of the size of the furnace. A cord is a variable measure for cut wood (Rackham, 1980), but to give an estimation of the amounts involved, working from information given by Rackham (1980), an 'Essex cord' represents about 3.6-3.8 cubic metres of wood. To produce this amount of wood, large areas of coppice must have been used, although it should be noted that wood could also have been produced by pollarding, from hedge trimmings and from the branches of felled trees. Also it is possible that wood may have been bought in from elsewhere. The historical information can therefore be interpreted as showing that areas of coppiced underwood, presumably including *Corylus*, would be expected to have been present. It cannot be ruled out, however, that other species such as *Quercus* and perhaps *Fagus*, were also important elements in the underwood system. As mentioned previously, when under

coppice management, the pollen output of these species will differ from that of *Corylus*. It is possible that they would not flower at all during the length of a coppice cycle.

Alnus is the most abundant arboreal pollen type. The pollen may be derived from trees growing in areas of wet soil such as along the sides of the streams feeding the pond or by the side of the pond itself. *Quercus* is the next most numerous arboreal pollen type, and it is possible that *Quercus* is the most common tree on the drier soils in the area. However its values are low in comparison with those of *Corylus*. In the sixteenth century there was great concern about the conservation of woods in the areas used by the iron industry. In 1541 an act of Parliment was passed that stated that after Michaelmas 1544, at least 12 standard trees per acre must be left after a wood was cut (Straker,1931). This would suggest that standard trees, such as *Quercus* would be common in the area, and that they would contribute a significant amount of pollen into the system.

A second enquiry held in 1591 (Yates, 1972) possibly explains the low amounts of *Quercus*. Here, it was asserted that a number of men, including Gleed and Martin had been responsible for felling and burning for fuel 2000 oaks of above one foot in diameter in Harting Combe and Nyewood (a wood to the south of this site). Evidence was given by men employed by the furnace, who stated that they had used oak trees as well as cordwood in the production of charcoal for the furnace. The removal of these trees would have the effect of opening the canopy above the *Corylus*, enabling it to increase its flowering, and would explain the high *Corylus* and relatively low pollen values of *Quercus* and *Fagus*.

Little is seen of the removal of *Quercus* from the site in the pollen record. There is a relatively large drop between the first two samples, but as only one sample shows relatively high values of *Quercus* the evidence would appear to be weak. It is possible that the earliest sediments in the pond have not been collected, as the use of a Russian borer in the collection of the core inevitably means the bottom few centimetres cannot be recovered.

However, the high numbers of fern spores seen in this assemblage, could provide secondary evidence for such a clearance as they could be derived fom eroded soils in the catchment, disturbed as a consequence of the removal of the trees.

The drop in *Alnus* is also probably a reflection of the increased utilisation of the trees in the area, with individuals being felled or possibly coppiced or pollarded.

The low numbers of herbaceous pollen suggest that, for the greater part of any coppice cycle, *Corylus* formed a relatively closed canopy. However, after parts of the area were cut, increased light reaching ground level would be expected to increase the abundance of herbs. The single record of *Melampyrum* could be important here as members of this genus can be associated with coppice, particularly oak coppice (Rackham, 1980).

Zone CP1B.

The dramatic drop in *Corylus* and increase in herbaceous and dwarf shrub pollen suggests that much *Corylus* has been cleared from the area, thus reducing shrub canopy cover.

The regeneration of trees on this site may have been prevented by grazing. The high numbers of *Plantago lanceolata*, together with significant amounts of Liguliforae, *Potentilla* and *Rumex acetosa* indicate the increased importance of pastoralism in the area (Behre,1981; Moore, Evans and Chater,1986). Historical records (Yates,1972) suggest that the cutting of *Pteridium*, and possibly burning were also important in keeping the area open, as both practices caused the removal of tree seedlings.

The increase in *Calluna* and, to a lesser extent, *Vaccinium* show that heathland is now present in the area. However, the high levels of Gramineae and the diversity of herbaceous pollen types, particularly those indicating grazing, suggest that the local vegetation was a mosaic of heath and grassland rather than pure heath. It is of course possible that some of the Gramineae is derived from plants in a reed swamp community fringing the pond. The records of *Sparganium* and *Typha latifolia* in the assemblage suggest that this habitat has now formed around the pond.

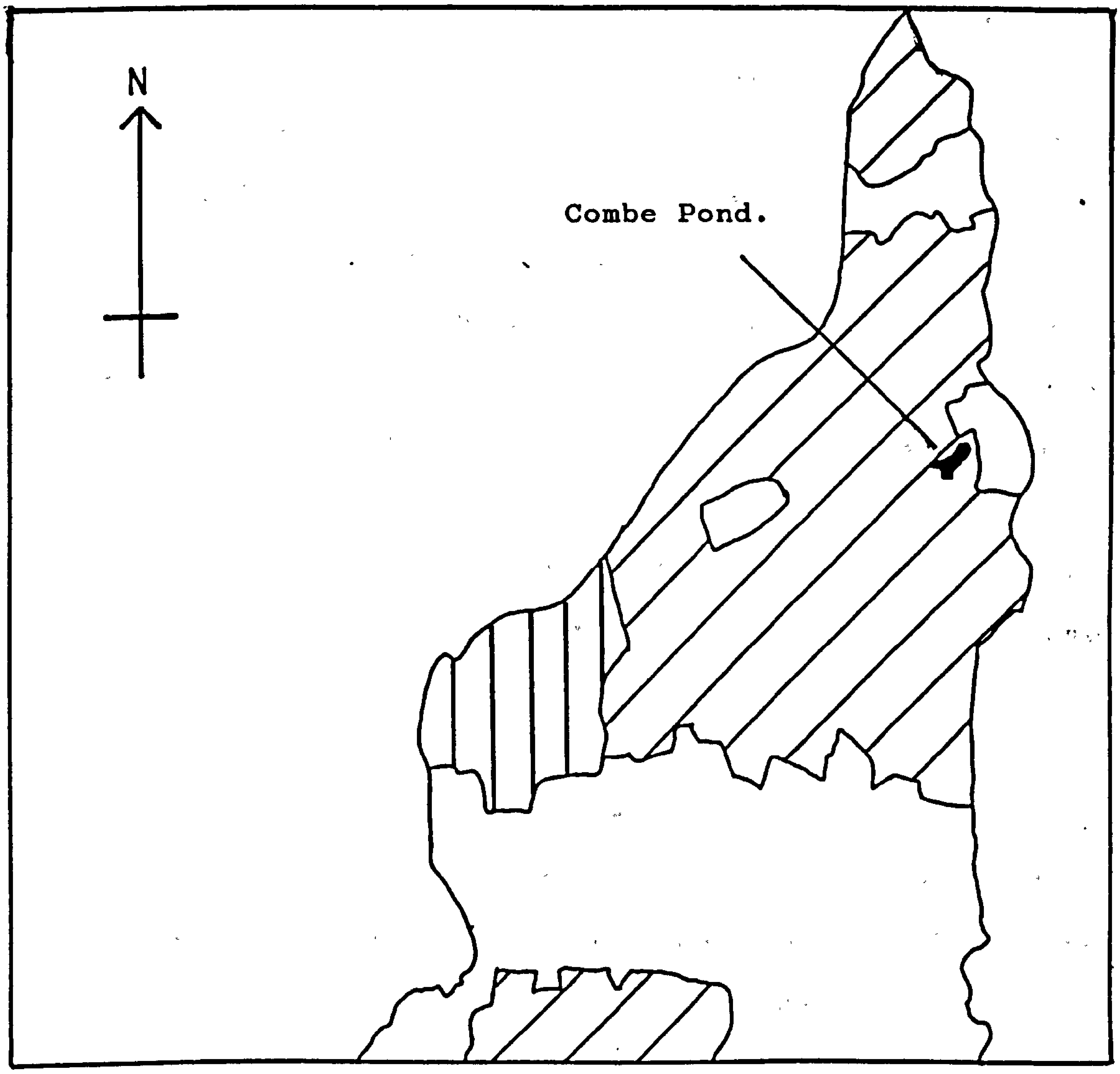
Again the study of the local historical records by

Yates (1972) supplements the information from the pollen diagram. Fig. 7.7 taken from a map of 1632 shows the area of 'down and heath' recorded at the time. For the local people the removal of the trees from Harting Combe was economically favourable as they had common grazing rights to the area. One document referring to the site stated, "and that the said inhabitants of Rogate, Rake ... do now the said woods being cut down and the soil cleared of tree receive, perceive and take more profit, and benefit of and by the herbage and feeding than they did to their own particular shares make of and by the pannage and feed while the said woods were standing...".

Other pollen indicators in this assemblage show, however, that other agriculural land-use practices were present in the pollen catchment area. *Fagopyrum, Spergula arvensis* and possibly cereal pollen, show the presence of arable farming.

When the arboreal pollen spectrum is studied, perhaps the most important feature is the increase in the frequency of *Pinus*, which is likely to be a reflection of the first plantations of this species in the area. The records of *Castanea* suggest that this tree was more frequently planted after this time.

Quercus would still seem to be relatively important, but the increase in *Fraxinus* could be important as its pollen is under-represented in pollen spectra (Andersen,1980; Bradshaw,1981). The fact that there are also still significant numbers of *Corylus* present suggests that there could have been some coppice woodland



Scale. 0 1 2 3 (Km.)

Key.

- Wood. - Down and Heath.

Fig. 7.7 Sketch map showing land utilisation c.1632 in the Parish of Rogate, in the vicinity of Combe Pond.
(Re-drawn from Yates, 1972)

still present. Much of the area around the pond was then devoid of canopy cover and this might have implications for the size of the pollen catchment. Such a large open area (see Fig. 7.7) is likely to have a relatively high input of pollen derived from more regional sources.

The increase in *Betula* towards the top of the zone suggests that there may be some encroachment of this species on the area of heath. The *Anemone* and *Mercurialis* in the spectrum, pollen types possibly derived from plants associated with woodland, and unlikely to be transported far, add evidence to there being some woodland remaining locally.

The steady recovery of *Alnus* is either due to its re-establishing itself along stream and pond sides, or because it was not being so intensively coppiced or pollarded, allowing it to flower more heavily. The same is likely to be true for the increase in *Salix*. The record of *Frangula* also suggests that this species was part of a carr or bankside community.

The increase in the numbers of aquatic taxa may be associated with the closure of the iron works and the subsequently less intensive use of the pond.

Zone CP1C.

The decline in *Calluna* and Gramineae and the increase in *Betula, Pinus, Quercus* and *Fagus* show the renewed importance of woodland in the area. Two major factors may account for these changes. Firstly, a fall in the intensity of grazing in the area would allow the establishment of tree seedlings on the heath and lead to the formation of subspontaneous secondary woodland. The level in grazing could have fallen as a result of the discontinuation of commoning. Secondly, a certain degree of active planting of trees may have taken place.

The reformation of a closed canopy over much of the local area accounts for the drop in the numbers of herbaceous pollen types that is seen in this assemblage.

The fall in *Corylus*, even though there has been a recovery of local woodland, could be due to changes in woodland management. Woods no longer managed to produce *Corylus* coppice would have developed a heavier canopy of standard trees, which would then lead to a reduction in the flowering of *Corylus*. Other factors that could be important are the establishment of higher numbers of *Pinus* in the area, either planted or self-seeded, which would decrease the area of deciduous woodland. The increase in *Castanea* also raises the possibility that this species had replaced *Corylus* as the most important coppice plant locally since plantations of this species are well known in the region.

High numbers of *Alnus*, which are seen towards the top of the diagram, almost certainly refect the establishment of individual trees and areas of carr vegetation persisting at the site today. Likewise, the relatively high values of *Typha*, *Mentha*, and Cyperaceae are probably largely derived from the area of reed swamp from which the core was taken.

7.3 Summary.

The comparison of the information obtained from the pollen analysis with that from the historical records gives no reason to doubt that the pond sediments give a complete record of the vegetation of the area from when the pond was originally built. It is of note that the date for this pond of 1588 is close to the date, suggested by ^{14}C analysis for the construction of Hammer Pond at Chithurst discussed in Chapter 5. Apart from showing that the iron industry must have been an important part of the local economy at this time, it raises the possibility that the two sites could have been related, with some of the iron produced at Combe Pond being further processed at the Hammer Pond site.

Before the construction of the pond and ironworks it would appear, again from the study of historical records (Yates, 1972) that Harting Combe and the nearby Fyning Wood, were still heavily wooded. It was stated that in these areas many of the local tenants "had free commonage for pannage and mast and feed for all their swine little and great" and "for great cattle or sheep....the pastures of and in those woods were of small or no validity". The possibility that the woods were used for pannage is often taken to imply that acorns were the principal foodstuff taken by the pigs. Mast is also mentioned in the document, presumably referring to beechmast. Therefore this source suggests that the woodland in Harting Combe consisted of a mixture of oak and beech.

The nature of this woodland seems to have been dramatically changed by the iron works. Many of the mature trees in the area appear to have been lost, and the area dedicated to underwood production to supply the ironworks with charcoal. It could have been such actions, which included the initial use of timber trees as fuel, that led to the belief that it was the iron industry that destroyed much of the woodland of the Weald. This would have caused the laws such as the one of 1541, mentioned earlier, being passed. However, the view that the ironworks destroyed woods is mistaken. If the iron industry cleared such standard trees it was to provide more space for growing underwood (Rackham, 1986); this would not lead to the loss of woodland.

Pollen evidence from the zone CP1B shows, however, that woodland was lost from this site, and that it was replaced by heathland. As mentioned earlier, the historical evidence suggests that this clearance and the subsequent maintainace of the heath was achieved by the desire of the people of the area to provide common grazing. At this site at least it would appear that the iron industry did not cause the destruction of the woodland, but apparently preserved it for longer than might otherwise have been the case. The clearance must have taken place after the demise of the ironworks, as it would have meant the loss of its fuel supply. It is possible that the closure of the furnaces brought about a change in the local economy, that caused the local inhabitants to rely on pastoralism more heavily. This in turn resulted in the need for extra grazing. The former presence of heath at the site, on the Weald Clay, shows that this vegetation type can occur in the area on strata other than the Lower Greensand, especially when, as is the case here, there are sandstone outcrops in the Weald Clay.

The subsequent loss of the area of heathland and the apparent reafforestation of the area shows parallels with the recent history of both the Burton Mill Pond and Hammer Pond sites. Some of the trees, especially the conifers, are likely to have been planted. But decline in pastoralism, and or enclosure of some areas is again implicated.

CHAPTER 8 - FURNACE WOOD.

8.1 Site Description.

The site that this core was taken from is an artificial pond (grid reference SU 879 282), roughly 2km South West of the village of Fernhurst, West Sussex. As its name suggests it is associated with the site of a furnace once used in the iron industry. The pond lies on the Weald Clay formation. However, there are outcrops of sandstone and areas of head deposits in the region of the site which affect the soils in this locality. Fig 8.1 gives a geological sketch map of the site.

The pond is fed by a number of streams, rising from the North, South and West of the site (see Fig. 2.1). The position that the core was taken from is shown in the map of the site, Fig. 8.2. Today the pond is surrounded by an area of mixed woodland, consiting of areas of coppice, coniferous plantation and some stands of *Fagus*.

8.2 Core Descriptions and Results.

8.2.1 Stratigraphy.

0.0- 20.5cm Brown lake mud with plant debris.
20.5- 23.0cm Darker, grey, lake mud with plant debris.
23.0- 27.5cm Black, humified plant debris and lake mud.
27.5- 72.0cm Grey/brown lake mud
72.0- 74.0cm Black, humified plant debris and lake mud.
74.0-105.0cm Grey/brown lake mud.

Scale 0 1 2 (km)

N

Key

Weald Clay.

Hythe Beds.

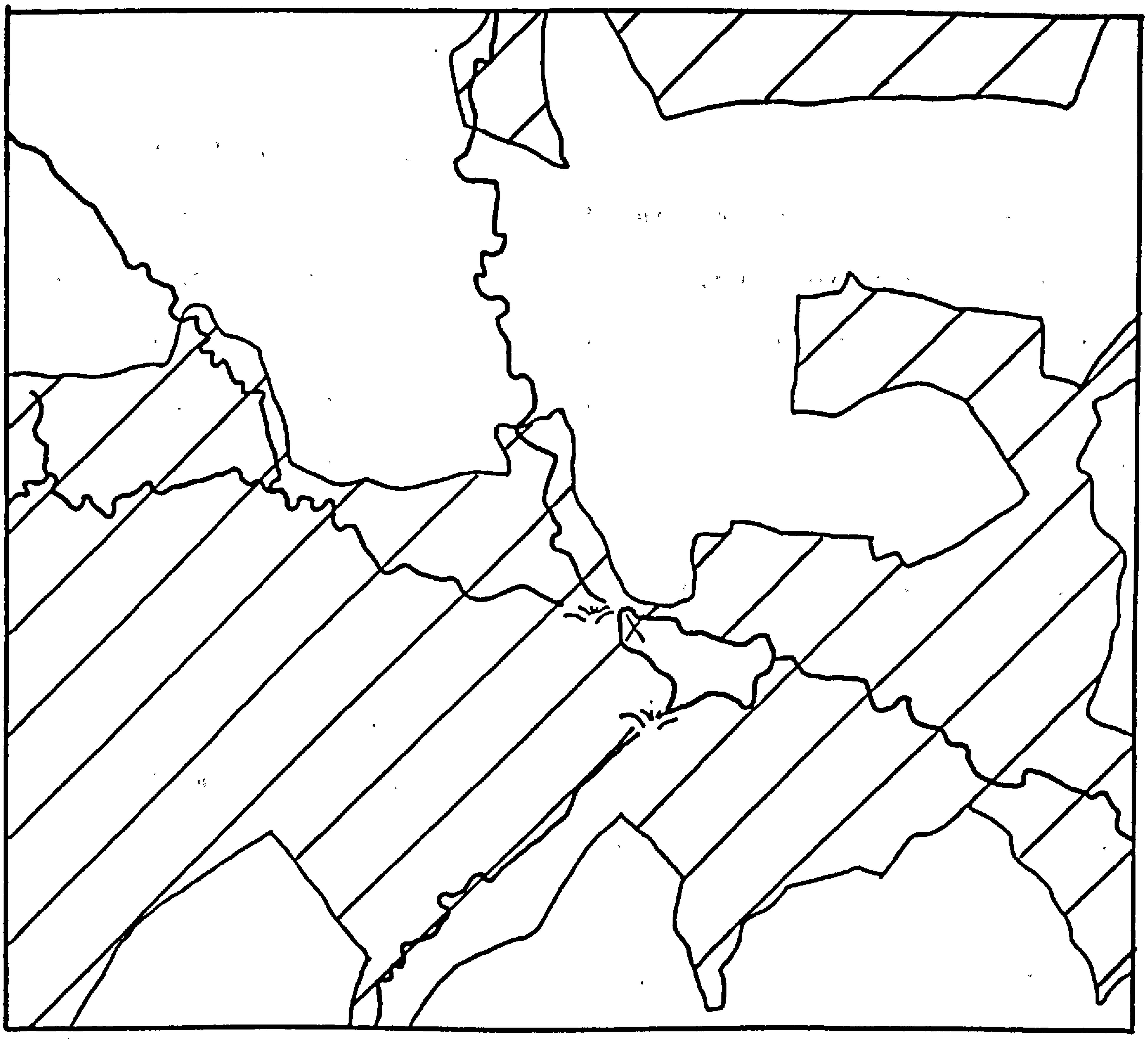
Sandstone in Weald Clay.

Head.

Atherfield Clay.

Alluvium.

Fig. 8.1 Furnace Wood - geological sketch map.



Scale. 0 0.25 0.5 (km)

N

Key.

- Wooded area.

Reeds.

x -Position core taken.

Fig. 8.2 Furnace Wood - Map of Site.

105.0-122.0cm Clay.

8.2.2 Pollen Stratigraphy.

The core was sub-sampled at every 4cm along its depth. At least 500 pollen grains and spores were counted from each sub-sample. Both the summary pollen diagram (Fig. 8.3) and the main pollen diagram (Fig. 8.4) were constructed with the values expressed as percentages of the total sum of pollen and spores (T.P.). Table 8.1 gives those pollen types recorded that were not included on the main pollen diagram.

8.2.3 Numerical Analysis.

The following pollen types were used in the statistical computer programs: *Pinus*, *Betula*, *Alnus*, *Quercus*, *Fraxinus*, *Corylus*, *Salix*, Crucifereae, *Plantago lanceolata*, Ligulifloreae, Gramineae, *Pteridium*, *Polypodium* and Filicales.

The results of these analyses are given in Figs. 8.5 and 8.6.

8.2.4 Local Pollen Assemblage Zone Descriptions:

Zone FW1A. Depth 122 - 98cm.

The upper boundary of this zone is between samples 26 and 25. Mathematically this split is found to be sinificant by all of the zonation programs, being assigned as either of the first or second importance in the whole core. The DECORANA plot shows these samples

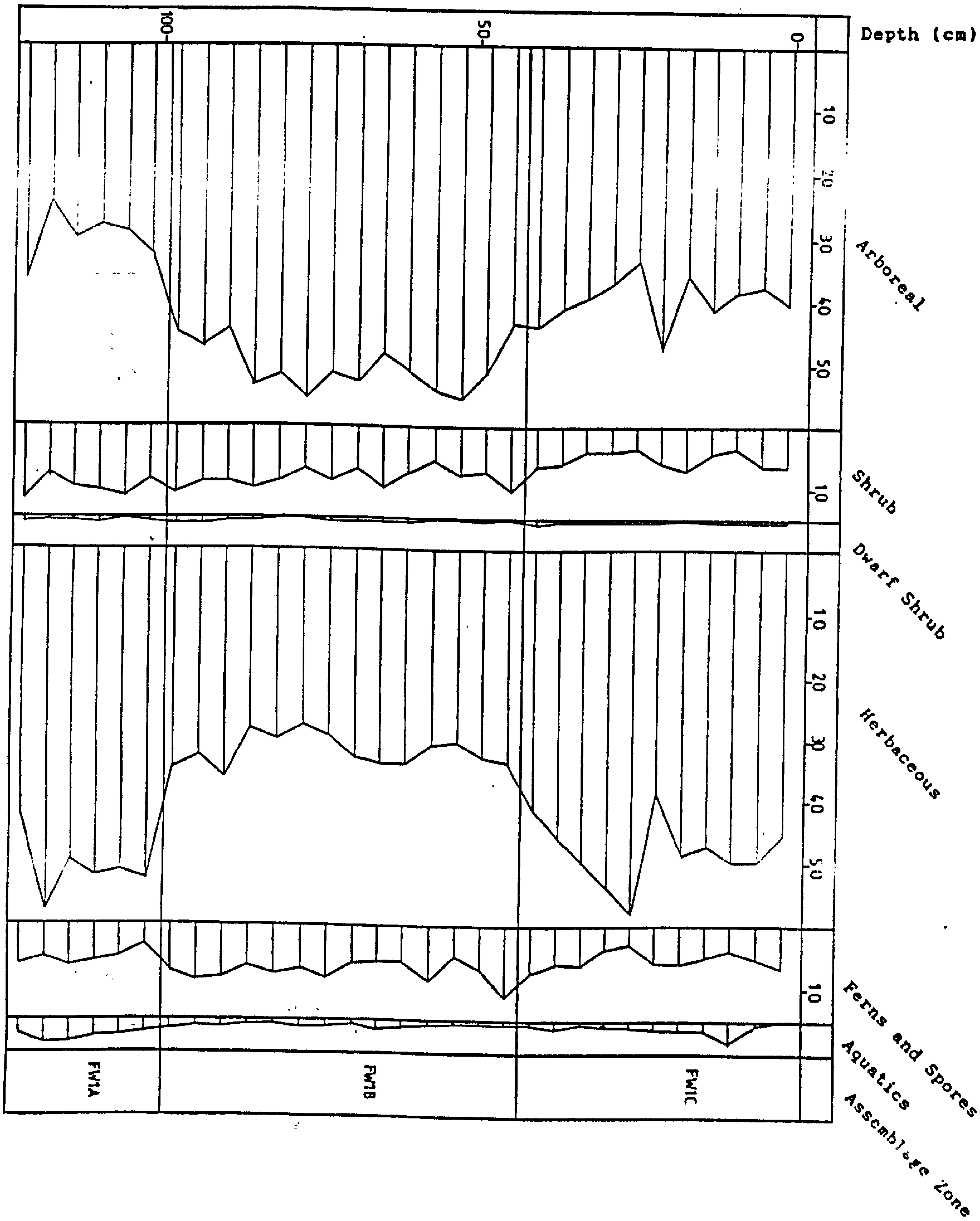


Fig. 8.3 FW1 Summary Pollen Diagram.

(Values expressed as percentage of sum of total pollen and spores.)

Fig. 8.4 FW1- Main Pollen Diagram
All values expressed as percentages of the sum of total pollen and spores.(+ represents values <1%)

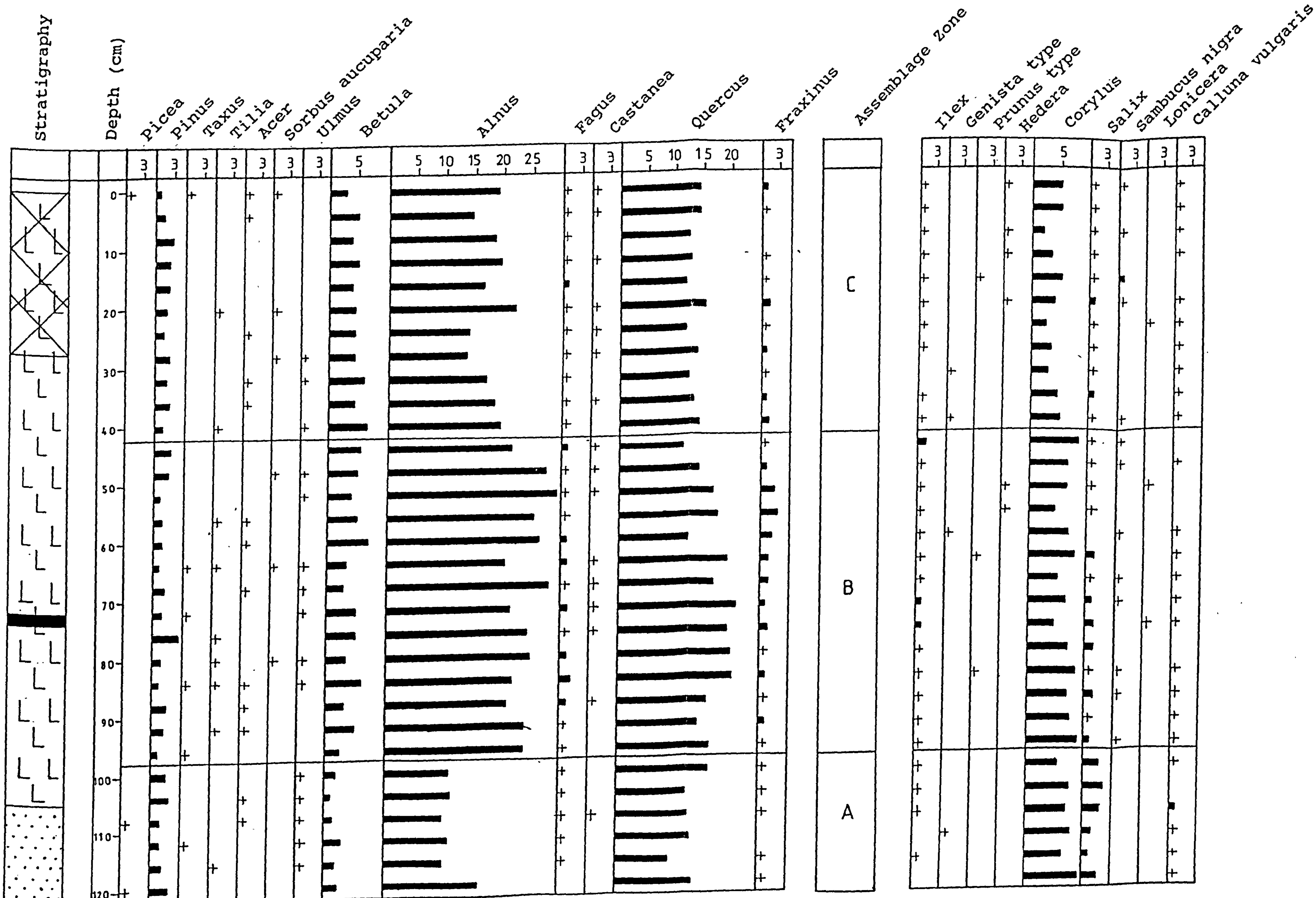


Fig. 8.4 Cont.


Ranunculus acris type
Cruciferae
Hypericum perforatum type
Caryophyllaceae
Chenopodiaceae
Leguminoseae undiff.
Trifolium type
Lotus type
Rosaceae undiff.
Filipendula
Rubus
Potentilla type
Geum
Umbelliferae
Mercurialis
Polygonum aviculare
Rumex acetosella
Rumex acetosa
Rumex obtusifolius
Fagopyrum type
Urtica type
Lysimachia vulgaris
Solanum dulcamara
Teucrium
Plantago media/major type
Plantago lanceolata
Galium type
Succisa
Bidens type
Carduus
Aster type
Anthemis type
Artemisia
Centaurea nigra type
Liguliflorae
Cyperaceae
Gramineae<30μm
Gramineae 30-50μm
Gramineae>50μm
3
10
20
30

Fig. 8.4 Cont.

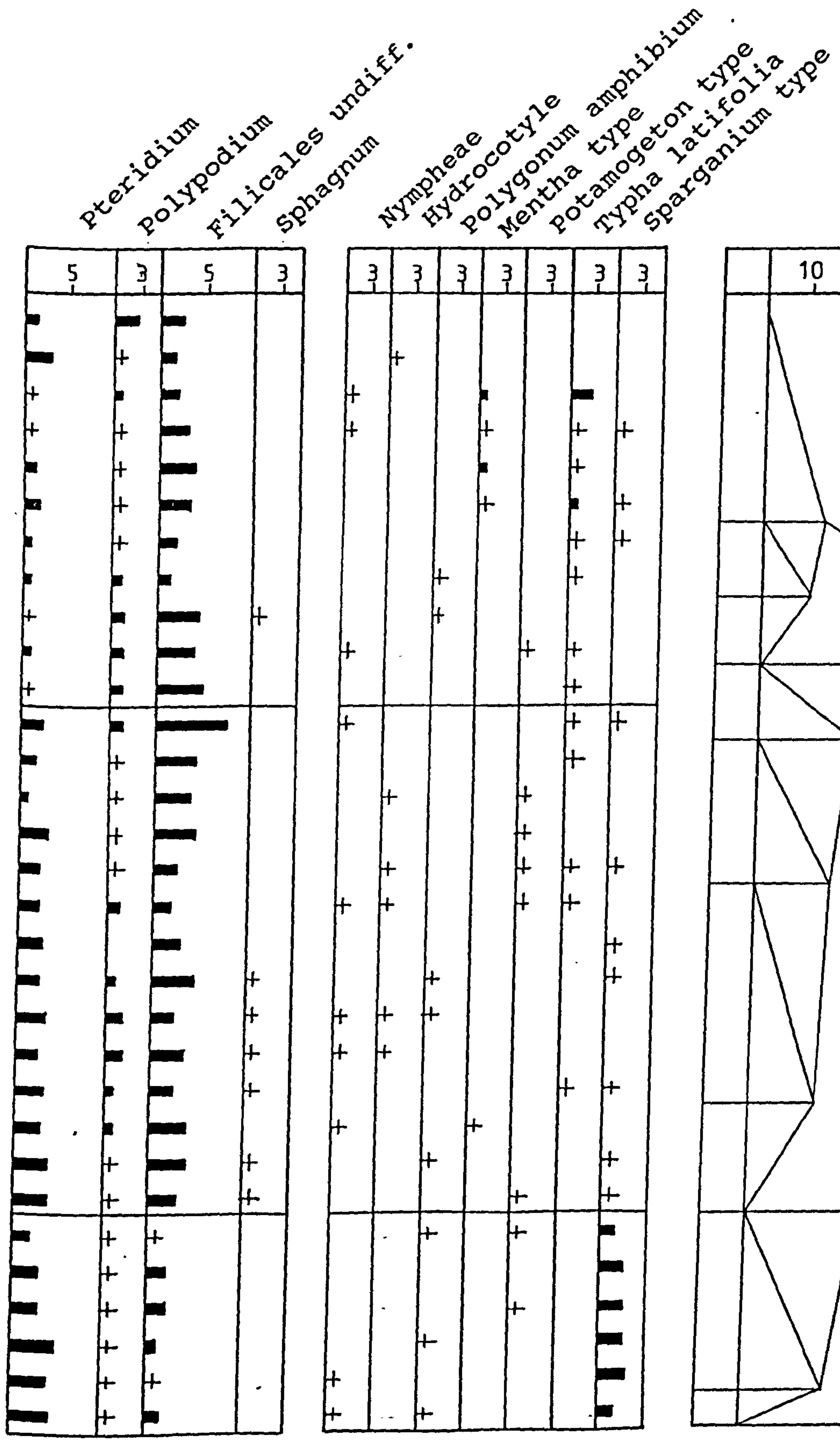
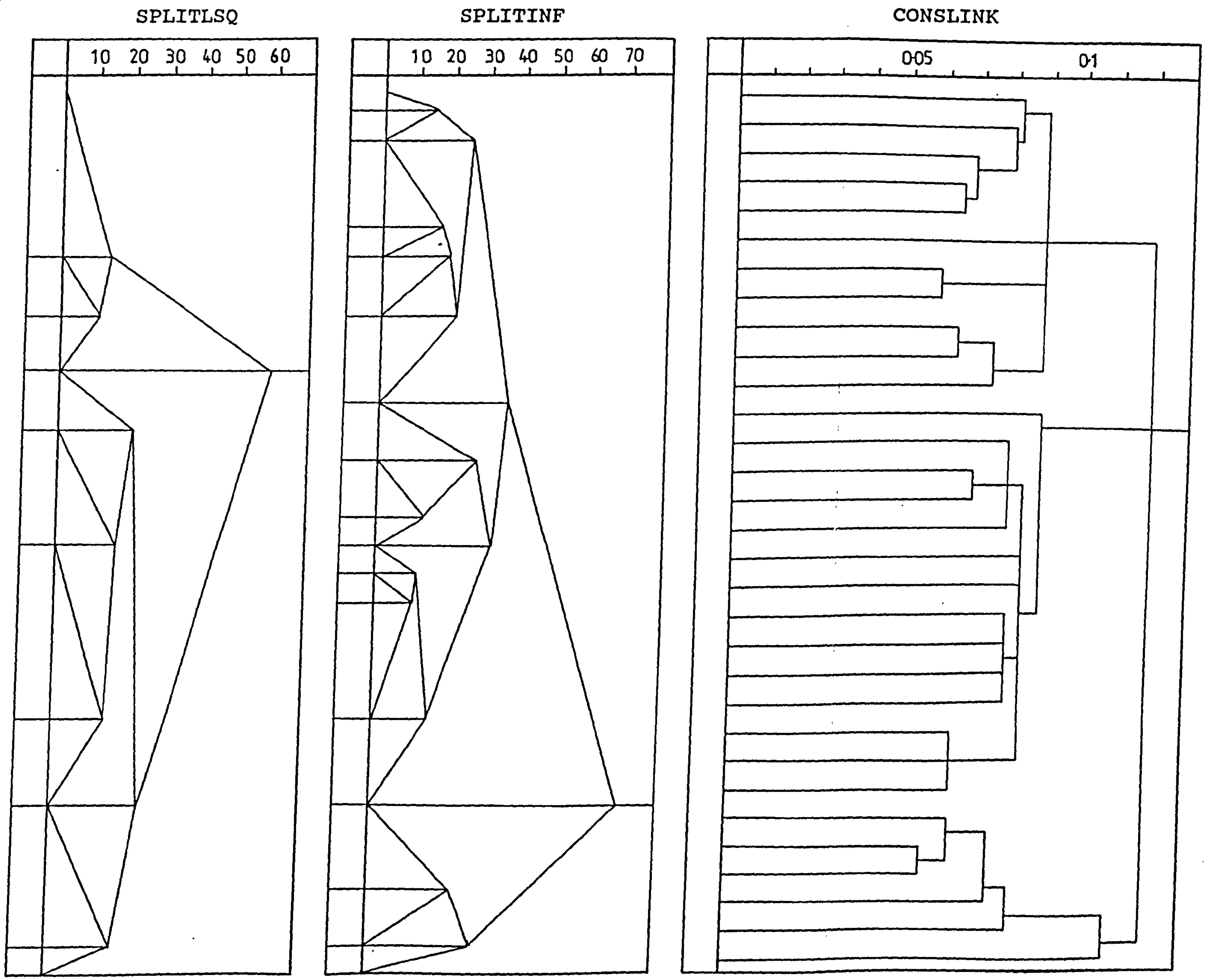


Fig. 8.6 FW1 Results of the Zonation program.

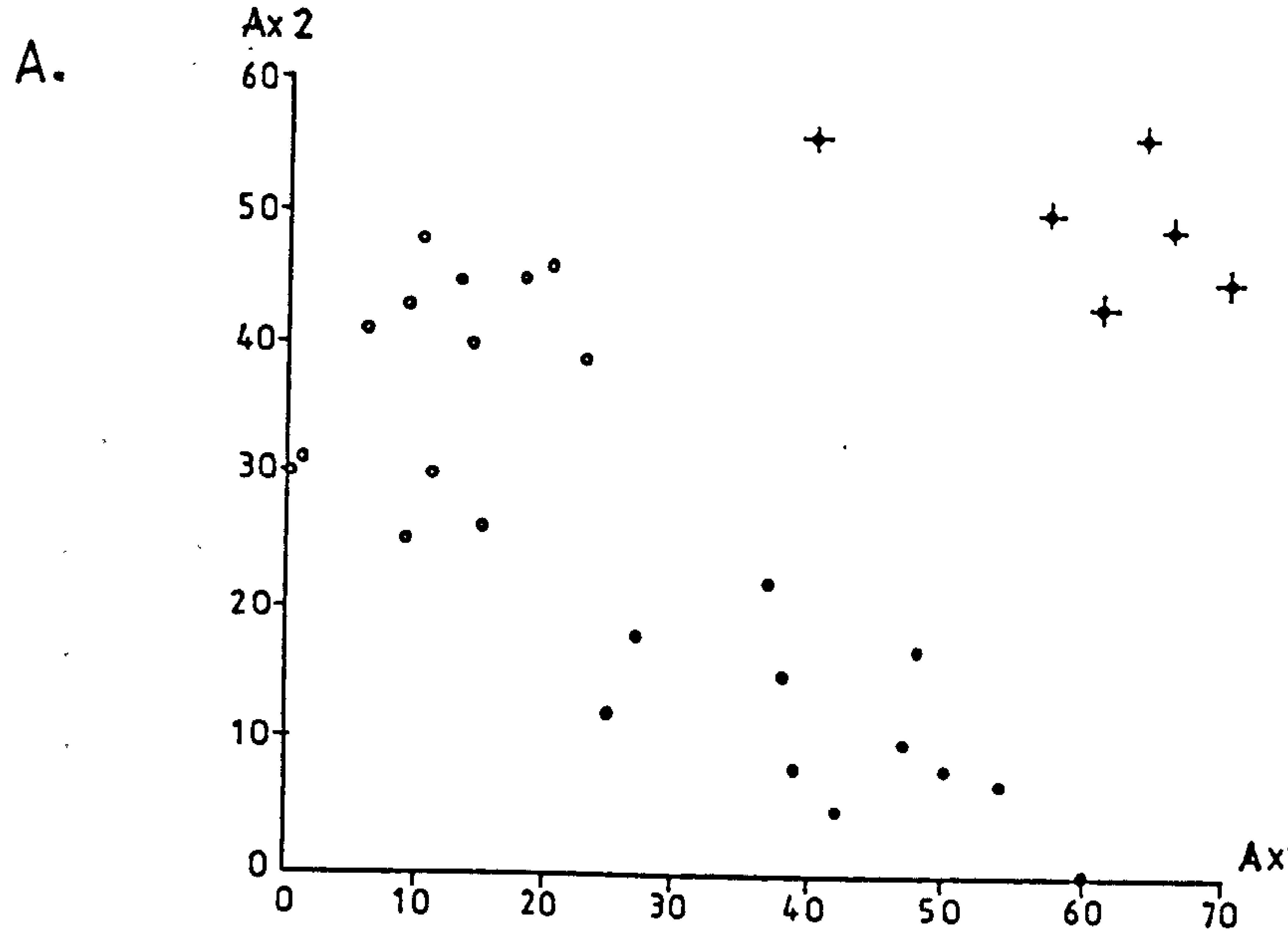


DEPTH (cm)	POLLEN TYPE
0-1	*Ononis* type
12-13	*Epilobium* type
16-17	*Aesculus*
24-25	*Vaccinium*, *Onobrychis* type, *Myriophyllum alterniflorum*
28-29	*Valerianella*
32-33	*Crataegus* type
36-37	*Symphytum*
40-41	*Vaccinium*, *Fallopia convolvulus* type
44-45	*Crataegus* type
48-49	*Epilobium* type
60-61	*Carpinus*, *Rosa* type, *Ononis* type
64-65	*Myriophyllum alterniflorum*
72-73	*Solanum nigrum*, *Veronica*
76-77	*Vicia sylvatica* type, *Callitriche*
80-81	*Chrysosplenium*, *Solanum nigrum*, *Callitriche*
88-89	*Echium*, *Ranunculus trichophyllus*
92-93	*Rhamnus catharticus*, *Papaver*
96-97	*Menyanthes*
100-101	*Sanguisorba officinalis*
104-105	*Viola* type
108-109	*Gentiana pueumonanthe*

Table 8.1 Pollen types found in the Furnace Wood core not included in the main pollen diagram.

112-113	*Helianthemum*, Scrophularaeaceae type, *Allium* type, *Osmunda*
116-117	*Linum catharticum, Cirsium, Nuphar*
120-121	*Frangula, Botrychium*

Table 8.1 cont.



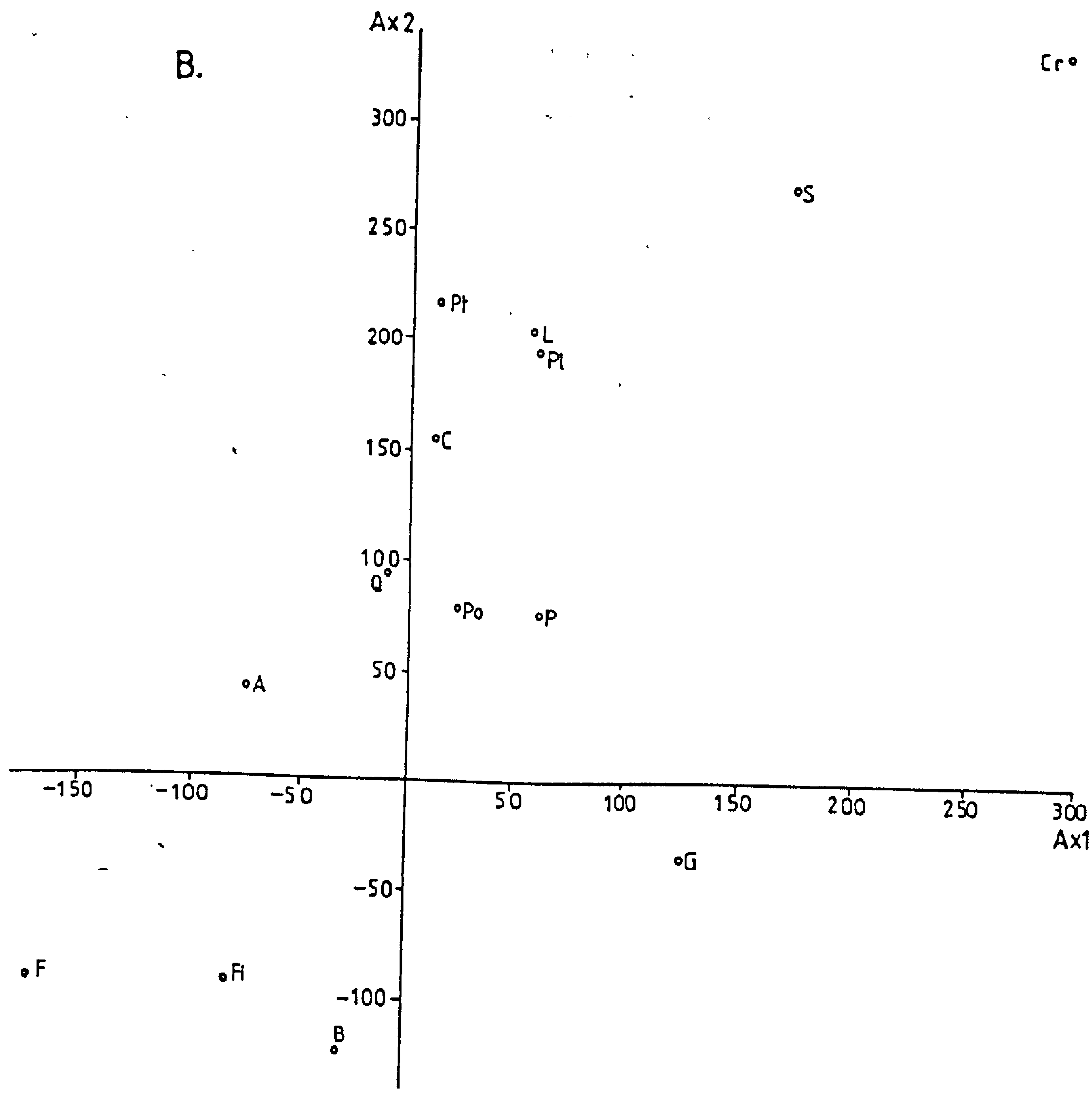


Fig. 8.5 FW1-DECORANA A-Samples B-Species

(Key overleaf)

Fig. 8.5 (cont.)

Key

A: Samples.

- -|- Assemblage zone FW1A
- o Assemblage zone FW1B
- ● Assemblage zone FW1C

B: Species.

P - Pinus	Cr- Crucifereae
B - Betula	Pl- Plantago lanceoloata
A - Alnus	L - Liguliforeae
Q - Quercus	G - Gramineae
F - Fraxinus	Pt- Pteridium
C - Corylus	Po- Polypodium
S - Salix	Fi- Filicales

forming a distinct cluster with high axis 1 and 2 values.

Numerically it is the herbs and grasses that are the most important elements in this assemblage. Gramineae dominates the assemblage, its values being stable through the zone averaging 38% T.P.. Cruciferae, *Plantago lanceolata* and Liguliflorae are the most numerous of the forbs, all averaging just over 2% T.P. with *Bidens*, Umbelliferae and *Filipendula* also being relatively numerous.

Quercus is the commonest arboreal pollen type, increasing slightly at the end of the zone reaching 17% T.P.. Numerically *Alnus*, and to a lesser extent *Betula* and *Pinus* are the only other important arboreal taxa. The values of all these pollen types are relatively stable, *Alnus* averaging 12% T.P. and *Betula* and *Pinus* both averaging 2% T.P..

Corylus is the most important of the shrubs present; again its numbers are relatively stable, averaging 7% T.P.. *Salix* is at its most numerous in this zone, reaching a maximum of 3% T.P..

Taxa also worth noting are *Pteridium*, the most numerous fern spore, which reaches 5% T.P. and *Sparganium* which dominates the aquatic pollen types and is also at its most numerous in this zone, averaging 2% T.P..

Zone FW1B. Depth 98 - 42.5cm.

The upper boundary of this zone, between samples 11 and 12, could be said to be mathematically slightly more confused than the boundary between assemblage zones FW1A and FW1B. CONSLINK shows it as being of joint first importance, SPLITINF of second importance, while SPLITLSQ assigns it as being of no significance. SPLITLSQ in fact finds the split between samples 10 and 11 as being the most important on the diagram.

The DECORANA plot, however, shows the samples making up this assemblage zone as forming a distinct cluster seperate from the other zones.

The most important feature of this zone is the increase in importance of the arboreal taxa. *Alnus* show the highest increase replacing *Quercus* as the most numerous arboreal pollen taxon. Its values show some degree of variation, falling between 21% and 30% T.P.. *Quercus* increases through the first half of the zone, reaching a maximum of 21% T.P.. It then decreases through the latter part of the zone to 11% T.P.. There is also a general increase in *Betula*, although its values also show a degree of variation, fluctuating between 3% and 7%.. That both *Fraxinus* and *Fagus* are at their most numerous in this zone again reflects the general increase in arboreal pollen.

When the shrub pollen types are examined it can be seen that the amounts of *Corylus* are much the same as in the previous zone, although, there is a decrease in *Salix*.

The increase in numbers of arboreal pollen is accompanied by a decrease in Gramineae; its values are generally stable, declining slightly in the middle portion of the zone, but average 24% T.P. overall.

After Gramineae, *Plantago lanceolata* and Liguliflorеae are the most numerous herbaceous taxa. The amounts of *Filipendula*, Umbellifereae, *Bidens* and especially Crucifereae present have all dropped since the previous zone.

The values of Filicales increase, reaching 7% T.P. by the end of the zone. *Polypodium* also increases slightly while *Pteridium* remains much the same.

Sparganium falls away in importance, but a greater number of aquatic taxa are recorded in this zone.

Zone FW1C. Depth 42.5 - 0cm.

Mathematically the similarity between the samples making up this zone is shown by the DECORANA plot, these samples forming a distinct cluster associated with low axis 2 scores, and medium axis 1 scores.

Gramineae rises again to dominate the pollen assemblage, reaching a maximum of 55% T.P. around the mid point of the zone. However, it then falls to 40% T.P. by the end of the zone. Values of the majority of the other herbaceous pollen types all drop in this zone.

Alnus is less important than in the previous zone; again its values tend to be somewhat variable, ranging between 15% and 22% T.P.. *Quercus* is more stable, averaging at around 13% T.P., similar to its values at the end of zone EB1B. Little change is seen in the other arboreal taxa.

A decline in the importance of *Corylus* is seen. Its values are relatively stable through the zone, averaging 4% T.P..

A general drop is also seen in the numbers of fern spores, Filicales is the most numerous, but drops to around 2% T.P. by the end of the zone, while *Pteridium* and *Polypodium* both average around 1% T.P..

Little change is seen in the aquatic taxa other than slight increases in the importance of *Mentha* and *Typha latifolia* towards the end of the zone.

8.2.5 Local Pollen Assemblage Zone Interpretations.

Although the size of this pond is relatively small, if one again takes into account the streams feeding the pond, the size of the pollen catchment area feeding it could be quite considerable (see Fig. 2.1). These streams, as is the case with the Combe Pond site, rise at a spring line at the junction of the Atherfield Clay and Hythe Beds of the Lower Greensand formation.

In the absence of ^{14}C dating, historical records give the best clue to the actual age of the sediments. Straker (1931), states that this was the site of the last ironworks that was working in West Sussex, which operated up until 1776. It is possible that an earlier 16th or 17th century furnace was present at the site: a pond at this site was marked on a map of 1680, but not on one of 1724. It therefore appears that the site was reconstructed in the latter part of the 18th century. The masonry of the spillway of the pond is consistent with this hypothesis. Therefore, it would seem that the earliest possible date for the sediments at this site is the late 18th century. However, the possibility that they might be younger than this has to be considered as the pond was not marked as being in water on the map of 1870 and 1903. This suggests it could have been restored some time in the early 20th century. This could mean that the pond could have been, at least in part, dug out after these dates.

Zone FW1A.

Clues from this pollen assemblage as to its age are at best vague. Chronologically one of the most important taxa is *Pinus*. Although a few individuals of this species may occur naturally in this area, most are due to plantations of this tree. The amounts of *Pinus* are relatively stable through the diagram as a whole, which suggests that this assemblage must date from after the first plantations of this tree in the area. Although this points towards a relatively recent date, Peterken (1981) mentions The Board of Agriculture Reports, 1790-1813 (Jones, 1961) as stating that the rate of tree planting increased towards the end of the eighteenth century, and in South East England was most common on recently enclosed heathland. It is therefore possible that the *Pinus* seen in this zone could be derived from plantations on the Lower Greensand outcrop in the area.

Straker (1931) mentions a report by Lower, that describes the vestiges of the ironworks left after its closure. Several acres of slag or cinders are mentioned, and it appears that the place of the head of water (presumably the pond), was occupied by an osier bed. It is possible to speculate whether the relative abundance of *Salix* pollen, especially when its low pollen productivity is taken into account (Bradshaw, 1981), and the high numbers of pollen of some weeds, such as Crucifereae, could derive from such an area.

A change in the stratigraphy from clay to lake muds and the upper boundary of this assemblage zone are separated by only a few centimetres. This raises the possibility that this point marks a break in the sediments, which resulted from the pond being dug out. It is therefore possible that zone FP1A could date from the reconstruction of the site in the 18th century, while the other zones may only date from the twentieth century, when it seems possible that the pond was again dug out.

The records of Pre-Quaternary spores in this assemblage (most probably Cretaceous, possibly derived from the Weald Clay itself), suggest that erosional processes are active in the catchment. This raises the possibility that this assemblage could include older Quaternary pollen also brought into the assemblage via reworking.

The rather mixed nature of the pollen assemblage suggests that a number of different vegetation types are represented. The high values of Gramineae pollen almost certainly indicate that much of the catchment area is open. Although some of the Gramineae pollen could be derived from local reed swamps containing *Phragmites* or *Phalaris*, the high number of different herbaceous pollen types in the assemblage supports the former hypothesis. Many possible indicators of pastoral activity, including *Plantago lanceolata*, *Rumex acetosa* and *Ranunculus acris* (Behre, 1981) are present. The importance of *Plantago lanceolata* combined with the high numbers of Gramineae, together with records of *Linum catharticum* and *Sanguisorba officinalis*, strongly suggests the presence of open pasture. Arable activity in the region appears to be indicated through records of *Fagopyrum*, *Polygonum aviculare* and the possible presence of cereal grains.

Arboreal pollen is also relatively numerous, which suggests that the vegetation in the catchment is a mosaic of woodland and open fields, and possibly includes areas of wood pasture. A number of pollen types included in this assemblage such as Gramineae Liguliflореae, Umbelliferae and *Pteridium* are all stated by Behre (1981) to be possible indicators of wood pasture (it must be remembered that many pollen types could possibly be derived from a number of different species, representing a number of different habitats). *Quercus* would appear to be the most important tree regionally. *Alnus* pollen, although numerous, is likely to be locally derived from trees growing in the vicinity of the pond, and confined regionally to the wetter areas of the pollen catchment. Although *Pinus* is consistently present through this assemblage, its relatively low numbers suggest that it is relatively unimportant in the pollen catchment area of the pond, and that these grains are more likely to indicate the regional presence of this species. *Betula* is the only other arboreal pollen type consistently present in this assemblage. Again its relatively low values suggest that it is not common in the area. It is therefore likely that there are few patches of disturbed ground that this tree is able to colonise in the pollen catchment area.

Corylus is relatively numerous, which raises the possibility of coppice woodland existing in the area (see Appendix 1). Again, if the furnace associated with the site was operating during the period covered by this zone (assuming the assemblage does indeed date from immediately after the restoration of the pond in the 18th Century, this would seen reasonable), areas of coppice might be expected to be present to provide fuel. It is, of course, possible that *Corylus* could be growing in other habitats in the area.

Zone FW1B.

Although there are differences in the values of the taxa present, the general similarity in the range of species represented suggest that the area is still made up of the mosaic of vegetation types outlined in FW1A. However, the general increase in arboreal pollen types shows some degree of woodland regeneration in the area.

Alnus has now become the most numerous arboreal pollen type, but it is still probable that the pollen is largely derived from locally growing trees. The values of

Salix are lower in this assemblage zone, which suggests that much of the area previously supporting *Salix* is now carrying *Alnus*.

Quercus is still the most important tree regionally. It increases, but not to as marked an extent as *Fraxinus* and *Betula*. As it is unlikely that active tree planting has been taking place, it is possible that the increase in *Quercus* and *Fraxinus* has resulted from the neglect of coppice in the area. If these species were once part of the underwood component of a coppice system, their stools would mature and eventually flower when coppice management ceased. This will increase the pollen output of these species in the area without actually increasing the number of individual trees present. Possible indicators of closed woodland include *Ilex*, *Rosa*, Filicales and *Polypodium*.

It must be noted, however, that the values of *Corylus* pollen are similar to those seen in the previous zone, and *Castanea* is more frequently recorded. This suggests that some coppice management could be still practised but there might have been a change in the species being used as the underwood component.

The increase in the numbers of *Betula* is possibly of more significance. *Betula* does regenerate well under shade, but commonly acts as an pioneer tree. This suggests that the management of land, once open, has lapsed allowing the invasion of *Betula*. It is also possible that areas of coppice, once abandoned, can be taken over by this tree (Rackham, 1980).

Although the values of Gramineae are lower in this zone, the records of *Plantago lanceolata* and *Rumex* spp. suggest that open pasture is still important in the catchment, while *Solanum nigrum* and *Papaver* could represent arable farming. It is possible that the drop in Gramineae is related to the increase in *Alnus*. Open areas, such as reedswamp, near the pond could have been invaded by this tree, or the drop in Graminae could simply be a statistical consequence of the increase in *Alnus* pollen.

Zone FW1C.

Considering the likely timespan covered by this diagram (possibly a continuous record from the 18th Century or a discontinuous sequence with the last two zones possibly representing less than 100 years) this zone can be seen as representing the relatively recent vegetation changes and includes the current picture. It will therefore highlight the changes in the vegetation of the pollen catchment brought about by modern farming and forestry practices.

Information about the size of the pollen catchment of the pond can also be gathered from this assemblage zone. Although today the pond is situated in an area of woodland (see Fig. 8.2), the levels of arboreal pollen in the spectrum are relatively low. However, the values of Gramineae are at their highest in this zone. The most reasonable interpretation of this is that it confirms the theory that much of the pollen in such a lacustrine assemblage is derived from areas away from the immediate vicinity of the pond, and is transported in the streams feeding the pond (Peck,1973; Bonny 1976, 1978).

The decline in arboreal pollen seen in this assemblage, could be due to an expansion of the amount of agricultural land. *Alnus* is the tree apparently most affected, which raises the possibilty of some of the wetter areas of land being reclaimed by drainage. *Quercus*, although less frequent, is still the most important tree in the catchment. One factor that may be important in the interpretation of the values of *Quercus*, however, was mentioned by Bradshaw (1981). He noted that the population of *Quercus* in South-East Britian contains many large, rather senescent individuals which have a relatively low pollen productivity. This suggests that *Quercus* will be under-represented in recent pollen spectra from this area.

The decline in *Corylus* is possibly linked to a decline in coppice management, but this could be compounded by the fact that in the recent past *Corylus* shows poor regeneration (Rackham, 1980). However, it would be incorrect to assume that the practice of coppicing *Corylus* has completely disapeared as areas of *Corylus* coppice can be seen in the woodland surrounding the pond today.

Although the increase in Gramineae suggests an increase in the amount of agricultural land in the catchment, it is accompanied by a decline in the levels of herbaceous pollen. This could be a reflection of the intensive nature of modern agriculture, the use of herbicides being a possible cause for the drop in these pollen types. Of course, pastoral indicators such as *Plantago lanceolata* are still present. *Valerianella* and *Onobrychis*, not previously found in the assemblage, are possible indicators of arable agriculture.

8.3 Summary.

The evidence from historical records suggests that Furnace Wood pond is rather younger than the other sites looked at in this study. The earliest date for the commemcement of this diagram is the latter part of the 18th Century, when it appears that the pond and ironworks present at this site were reconstructed. The picture is further complicated by what appears to be a break in sedimentation between assemblage zones FW1A and FW1B. This could imply that the last two zones might only date from this century.

It is reasonable to assume that assemblage zone FW1A does date from the 18th Century, covering the period immediately after the building of the pond when the furnace associated with the pond was operating. There is no evidence for any woodland clearance in this zone, suggesting that the activities of the furnace have not caused any great changes in the structure of the local vegetation. However, because there is some evidence that the ironworks dating from the 18th Century, were built on the site of at least one previous furnace (Straker, 1931), it is possible that the landscape could have been already altered by the activities of the iron industry. As for what was the fuel source utilised by the furnace, it seems reasonable to suppose that it was cordwood provided by coppice. There are two possible sources of evidence for the presence of coppice provided by the pollen diagram. Firstly the relative importance of *Corylus* pollen in assemblage zone FW1A can be argued to represent the presence of coppice (see Appendix 1). Secondly, an increase in arboreal pollen in assemblage zone FW1B could be due to neglect of areas of coppice in the area, possibly as a result of the fall in demand for its products after the closure of the ironworks. This increase in, mainly deciduous, arboreal pollen must have taken place within the last 200 years, a period normally associated with the loss of woodland. Bearing this in mind, and considering that the evidence from the pollen diagram suggests both pastoral and arable agricultural activity, it would seem very unlikely that there has been active planting of hardwood trees in this area within the recent past. Coniferous trees however have been introduced, even in the vicinity of the pond.

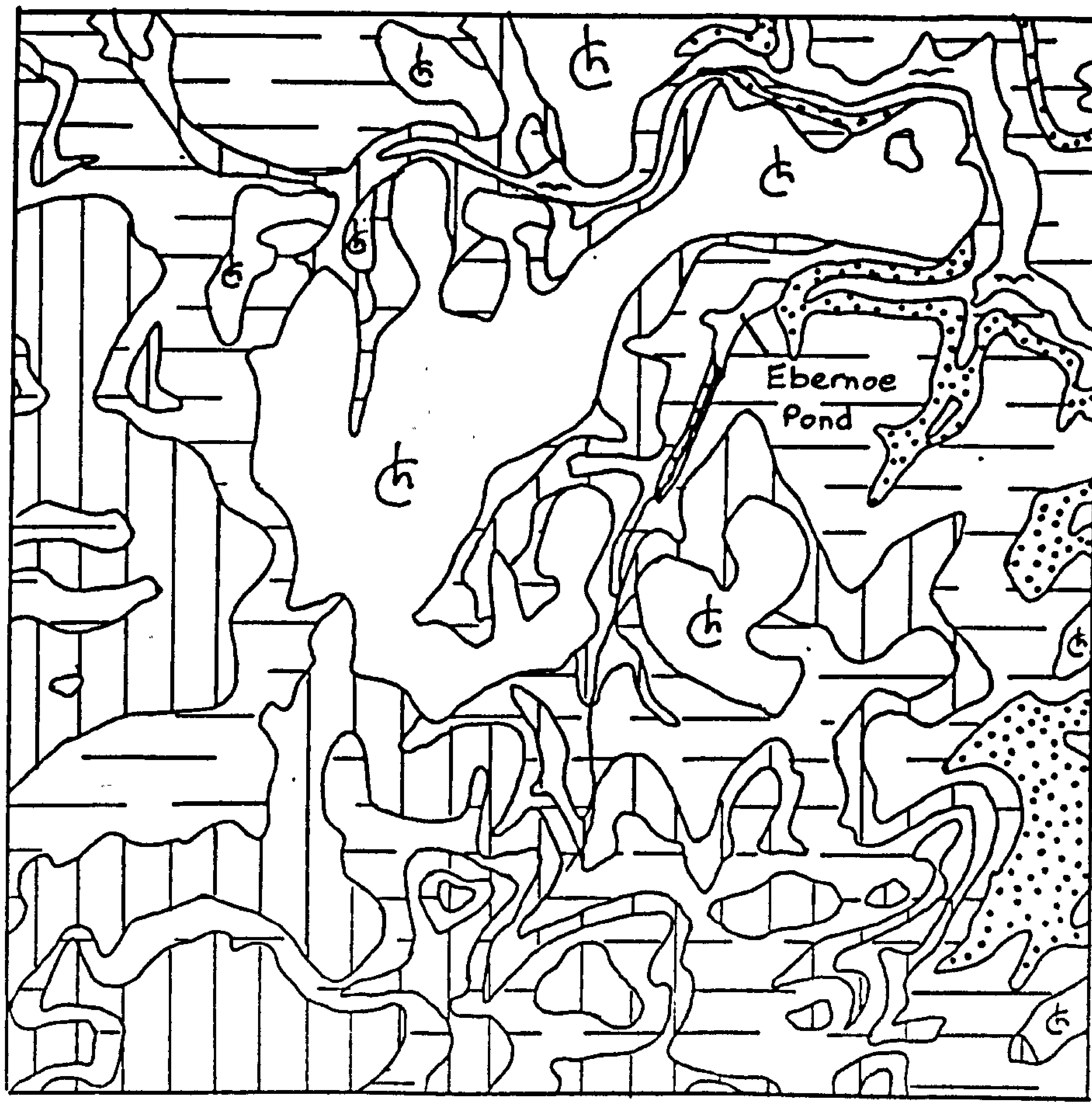
CHAPTER 9 - EBERNOE

9.1 Site Description.

The site this core was taken from was an artificial pond (grid reference SU 975 277) near the village of Ebernoe, about 5km north of Petworth. The site lies on the outcrop of Weald Clay. Fig 9.1 gives a geological sketch map of the area around the site. It can be seen that the nature of the outcrop, and hence the local soils are quite variable. The pond is fed by a steam that rises roughly 1.5km to the south at an interface between the Weald Clay proper and an outcrop of sandstone.

The pond is associated with a furnace used by the local iron industry. Investigation into historical records by Yates (in press), gives some information on the age of the pond. Unfortunately no direct records related to its construction exist, but other evidence shows it was built in the sixteenth century, some time after 1540.

The sketch map Fig 9.2 shows the position that the core was taken from, and gives the extent of present woodland cover. The two most important areas are Ebernoe Common and Willand Wood which today form a continous block of woodland. Ebernoe Common, today owned by the Sussex Naturalist Trust, is thought to be former commonland used for wood-pasture (Peterken, 1981). It is listed as a grade 1 site (of primary national importance to conservation) in the National Conservation Review of the Nature Conservancy Council (1977). Yates (1988) gives



Scale 0 1 2 (km)

N

Key

Weald Clay

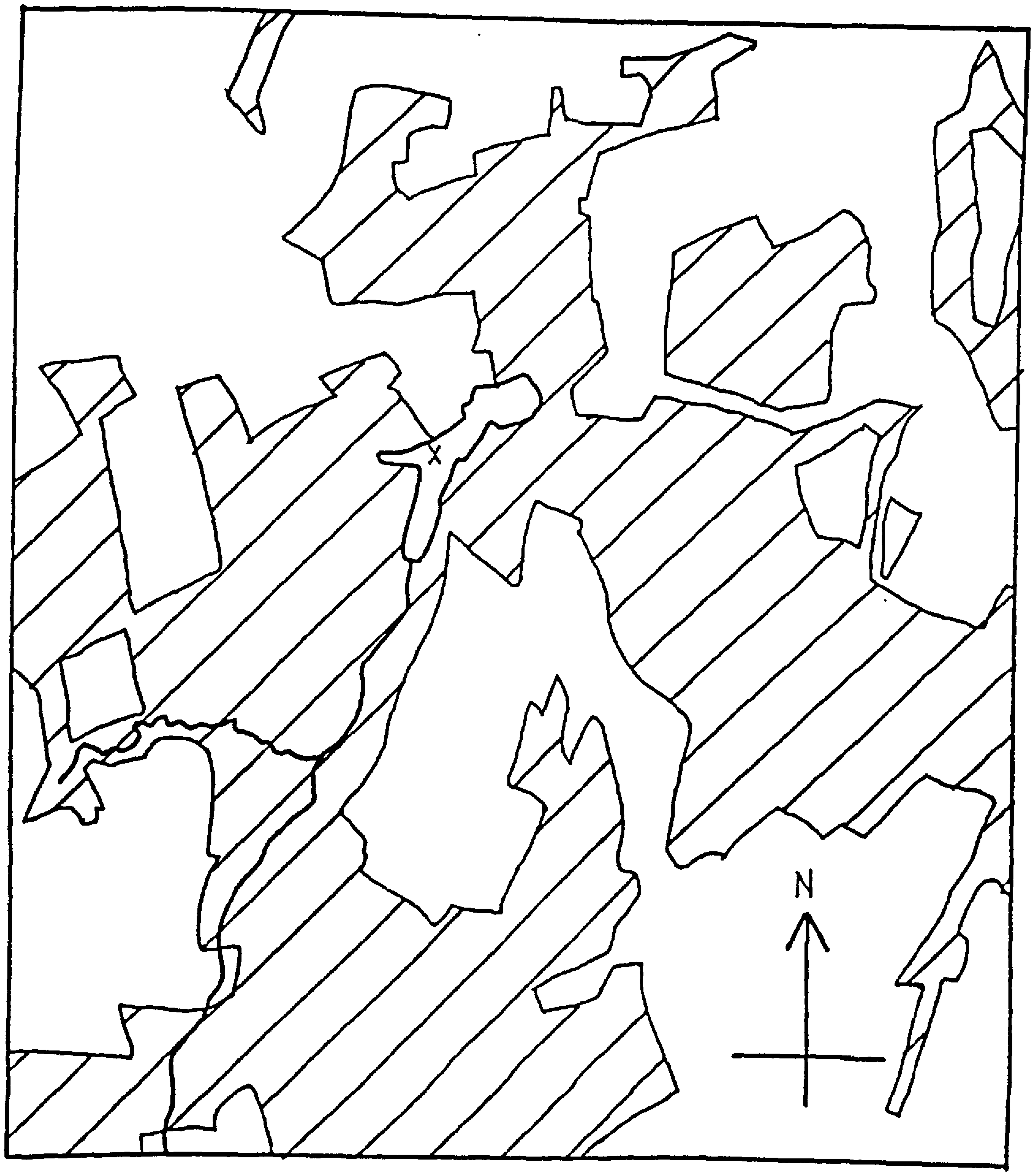
Sandstone in Weald Clay

Limestone in Weald Clay

Head

Alluvium

Fig. 9.1 Ebernoe - geological sketch map.



Scale 0 ——— 1 (km)

KEY.

- Wooded area

x - position core taken.

Fig. 9.2 Ebernoe Pond - Map of site.

a comprehensive vegetation survey of this common. Although not totally wooded, the common is largely covered by three main types of woodland. These are, closed *Fagus* woodland with some *Quercus* and a dense understory of *Ilex* and *Taxus*, a younger area of *Quercus*, *Acer* and *Fagus*, and woodland of *Quercus* and some *Fagus*. Willand Wood largely consists of *Quercus* standards and *Carpinus*, *Corylus* and *Fraxinus* coppice (Ratcliffe, 1977).

9.2.1 Core Stratigraphy.

0-306cm Lake muds.

9.2.2 Pollen Stratigraphy.

The core was subsampled every 8cm throughout its depth. At least 500 pollen grains were counted from every level. Both the summary pollen diagram (Fig. 9.3) and the main pollen diagram (Fig. 9.4) were constructed using pollen values expressed as percentages of total pollen and spores (T.P.). Those pollen types recorded but not included on the main pollen diagram are given in Table 9.1.

9.2.3 Numerical Analysis.

The following taxa were used in all of the statistical programs: *Pinus*, *Betula*, *Alnus*, *Fagus*, *Quercus*, *Corylus*, *Salix*, *Calluna*, Cruciferae, *Trifolium*, *Plantago lanceolata*, *Bidens*, Ligulifloreae, Cyperaceae, Gramineae, *Pteridium*, *Polypodium*, Filicales.

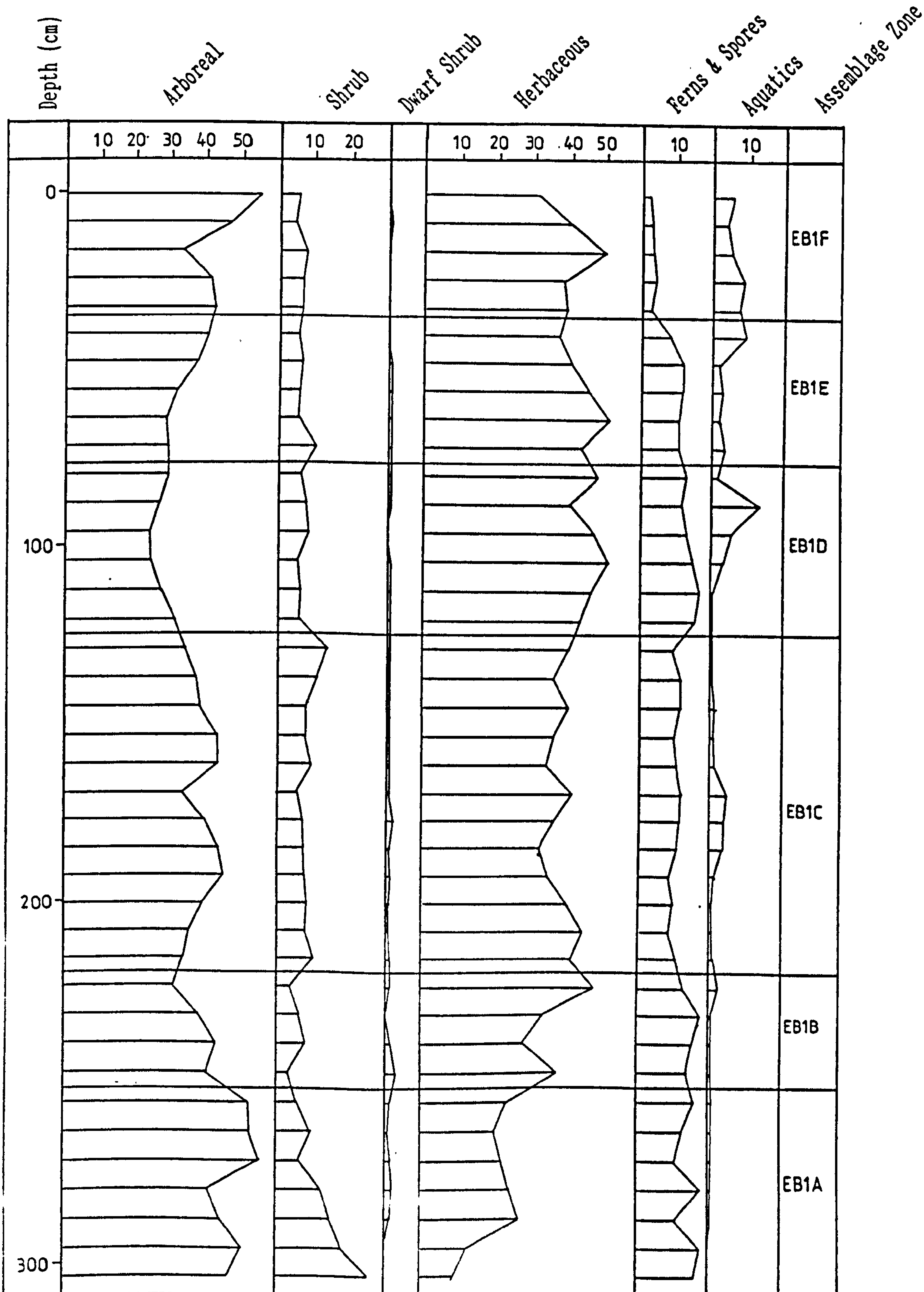


Fig. 9.3 - EB1 Summary Pollen Diagram.

(Values expressed as percentage of sum of total pollen and spores.)

Fig. 9.4 EB1- Main Pollen Diagram
All values expressed as percentages of the sum of total pollen and spores.(+ represents values <1%)

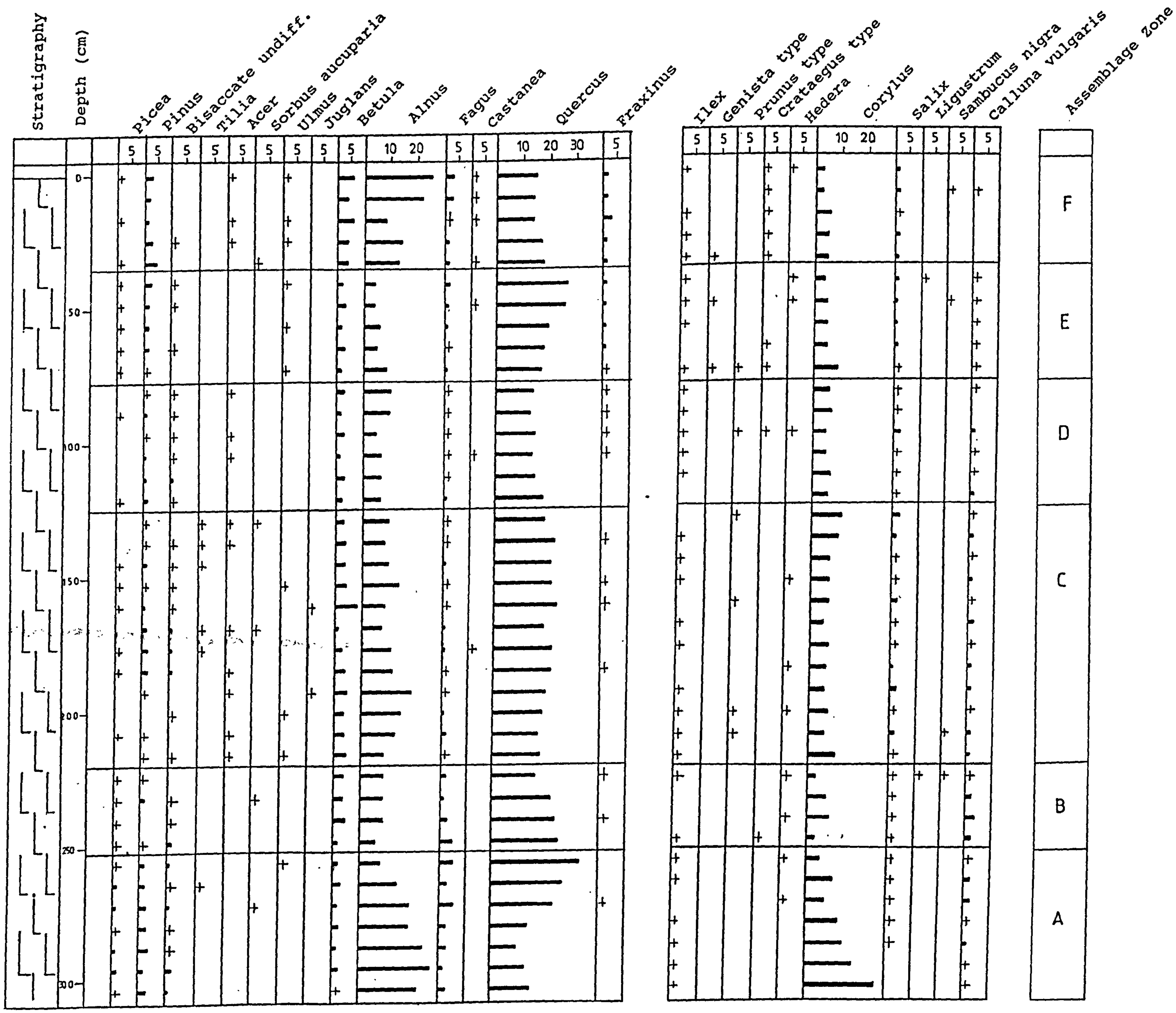
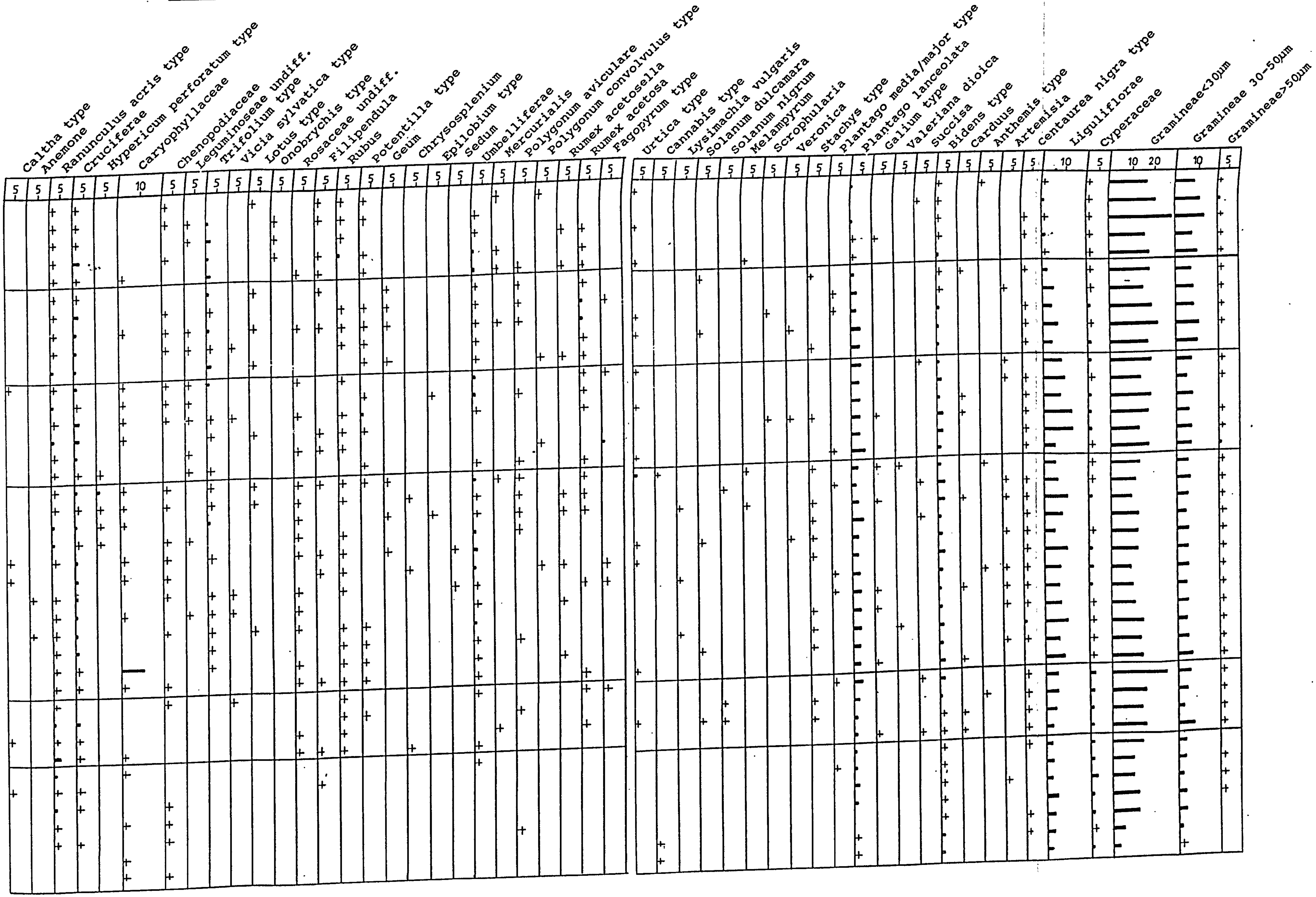


Fig. 9.4 Cont.



Caltha type
Anemone
Ranunculus acris type
Cruciferae
Hypericum perforatum type
Caryophyllaceae
Chenopodiaceae
Leguminoseae undiff.
Trifolium type
Vicia sylvatica type
Lotus type
Onobrychis type
Rosaceae undiff.
Filipendula
Rubus
Potentilla type
Geum
Chrysosplenium
Epilobium type
Sedum
Umbelliferae
Mercurialis
Polygonum aviculare
Polygonum convolvulus type
Rumex acetosella
Rumex acetosa
Fagopyrum type
Urtica type
Cannabis type
Lysimachia vulgaris
Solanum dulcamara
Solanum nigrum
Melampyrum
Scrophularia
Veronica
Stachys type
Plantago media/major type
Plantago lanceolata
Galium type
Valeriana dioica
Succisa
Bidens type
Carduus
Anthemis type
Artemisia
Centaurea nigra type
Liguliflorae
Cyperaceae
Gramineae<30µm
Gramineae 30-50µm
Gramineae>50µm

Fig. 9.4 Cont.

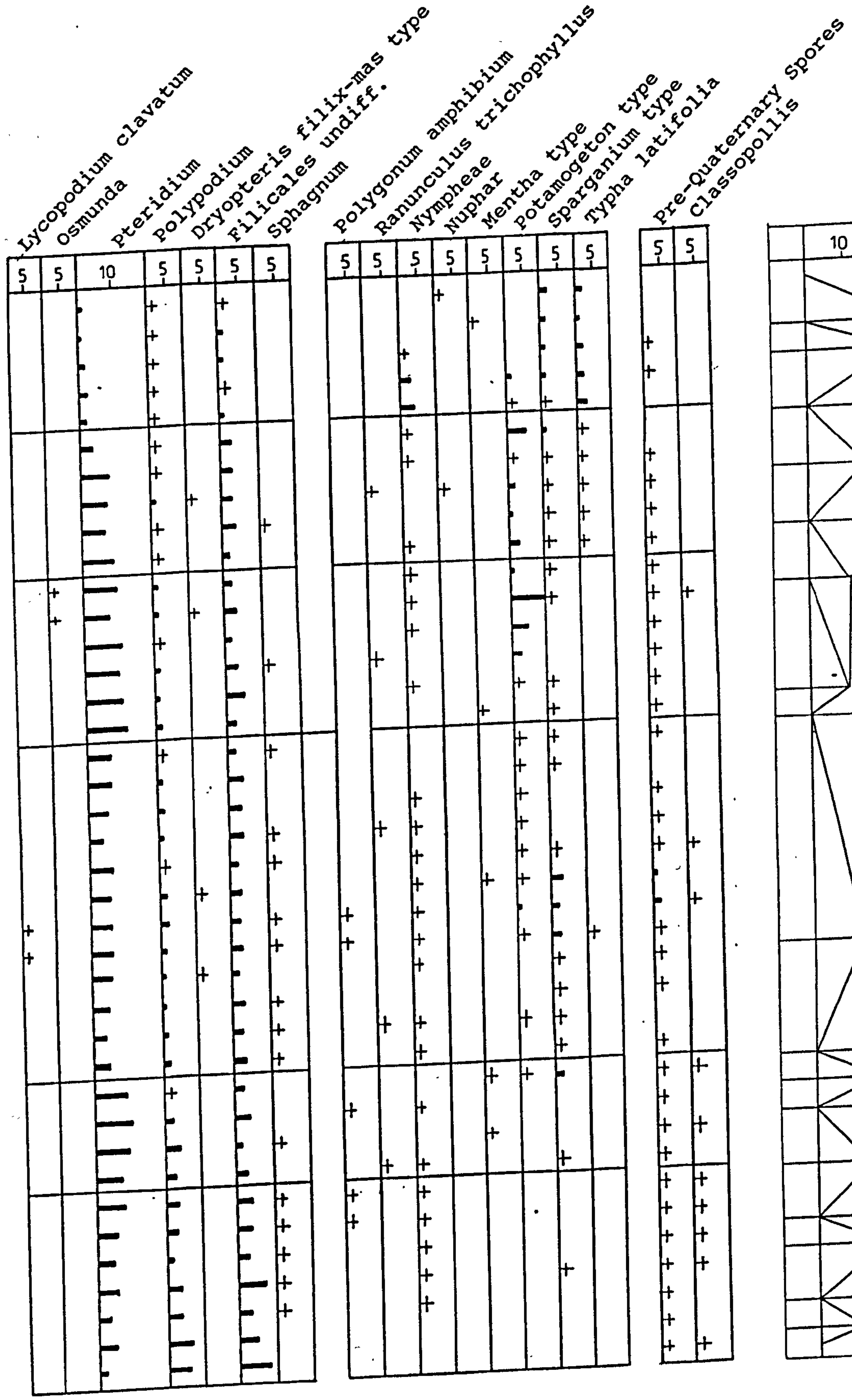
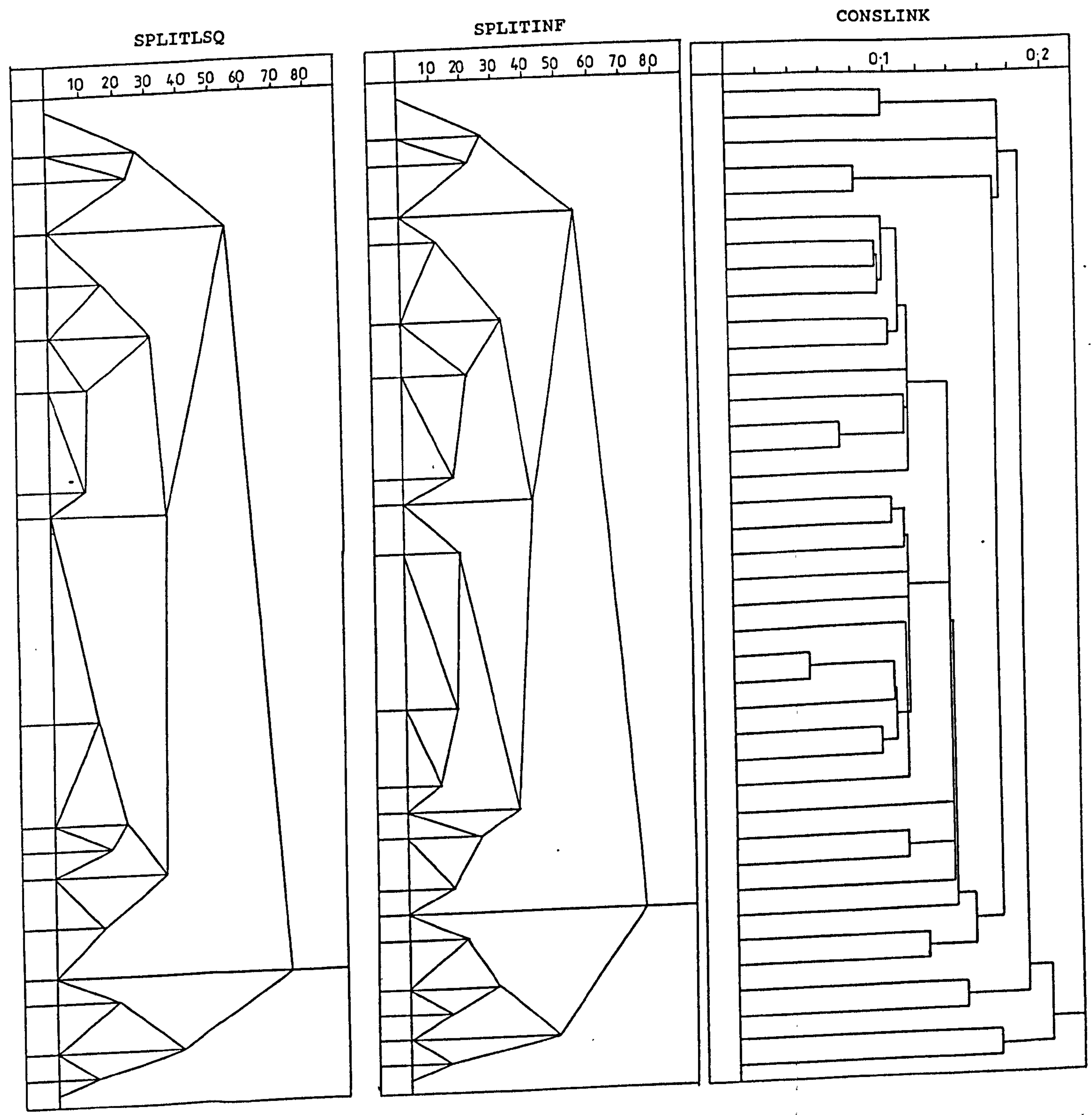


Fig. 9.6 EB1 Results of the Zonation program.



DEPTH (cm)	Pollen Type
0-1	*Carpinus*
8-9	*Aesculus, Lamium* type
24-25	*Lonicera*
32-33	*Rosa* type
48-49	*Sanguisorba minor*
56-57	*Hyacinthoides* type
64-65	*Papaver*
80-81	*Prunella* type, *Plantago coronopus*
88-89	*Helleborus, Myosotis* type
96-97	*Agrimoniae*
112-113	*Dryopteris dilatata*
120-121	*Pinguicula*
128-129	*Taxus, Platanus, Vaccinium*
136-137	*Rhinanthus* type, *Teucrium*
168-169	*Linum catharticum*
200-201	*Vicia cracca* type
232-233	*Drosera intermedia*
264-265	*Hydrocotyle*
272-273	*Menyanthes*
280-281	*Rumex obtusifolius* type

Table 9.1 Pollen types found in the Ebenoe core not on the main pollen diagram.

The results of these analyses are given in Figs. 9.5 to 9.6.

9.2.4 Local Pollen Assemblage Zone Descriptions.

Zone EB1A. Depth 306-252cm.

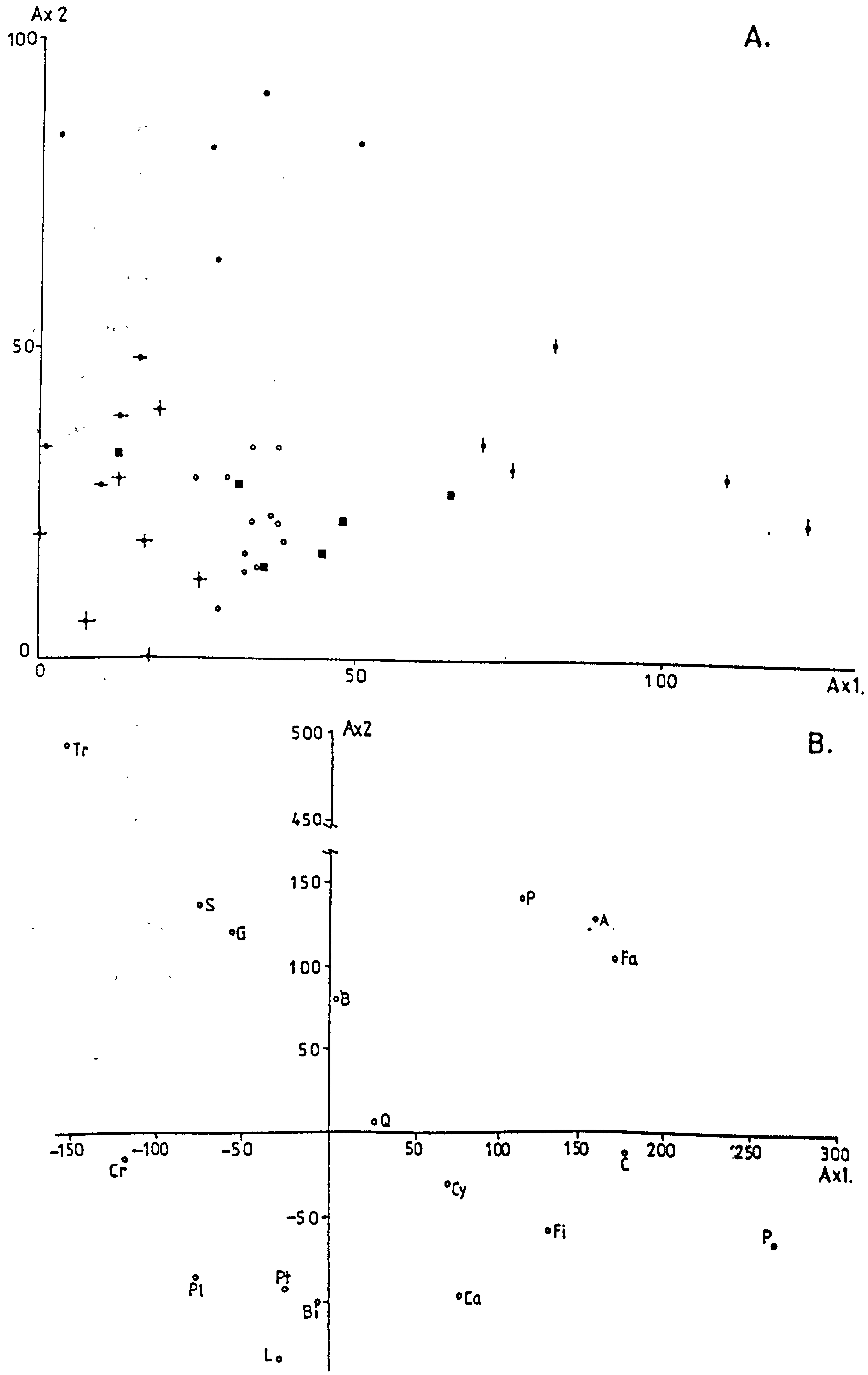
The upper boundary of this assemblage zone, between samples 33 and 32, is found to be significant by both SPLITLSQ and SPLITINF. However there is a marked difference in the assigned degree of importance. SPLITINF shows it as being the most important split in the diagram while SPLITLSQ finds it of only minor importance, and shows divisions within the zone as being more relevant.

The DECORANA plot shows these samples forming a relatively distinct cluster, but with a wide spread along axis 1. This can be seen as a reflection of the nature of the assemblage, in that major changes are seen in some of the major taxa.

Alnus is numerically the most important arboreal pollen type at the beginning of the zone, with values above 20% T.P. but it then falls away in importance to 8% T.P.. A similar pattern is seen with *Corylus*; however, its decline is more rapid, dropping from 25% to 5% T.P..

Quercus is seen to increase through the zone, reaching a value of 33% T.P. by the end of the zone, replacing *Alnus* as the commonest arboreal pollen type. Generally the other arboreal and shrub pollen types are stable.

The number of herbaceous pollen taxa present and



<u>Fig. 9.5 EB1-DECORANA A-Samples B-Species</u>

(Key overleaf)

Fig. 9.5 (cont.)

Key

A: Samples.

ɸ Assemblage zone EB1A

■ Assemblage zone EB1B

o Assemblage zone EB1C

✦ Assemblage zone EB1D

-o- Assemblage zone EB1E

● Assemblage zone EB1F

B: Species.

P - Pinus	Tr-Trifolium
B - Betula	Pl- Plantago lanceolata
A - Alnus	Bi- Bidens
Fa- Fagus	L - Liguliflorea
Q - Quercus	Cy- Cyperaceae
C - Corylus	G - Gramineae
S - Salix	Pt- Pteridium
Ca- Calluna	Po- Polypdium
Cr- Cruciferae	Fi- Filicales

their percentages are low through the zone. Gramineae, easily the most numerous herbaceous pollen type, is seen to increase through the zone from 4% to 16% T.P..

Of the fern spores in the assemblage only *Pteridium* increases through the zone from 2% to 8% T.P., *Polypodium* falls slightly to below 4% T.P. and Filicales remains stable.

Nymphea is the only frequently observed aquatic pollen type.

It is of note that this assemblage, and in fact all of the assemblages from this core, contain pre-Quaternary pollen and spores.

Zone EB1B. Depth 252-220cm.

The upper boundary of this zone, between samples 29 and 28 is found to be significant by SPLITLSQ and SPLITINF, but SPLITLSQ again finds a division within the zone to be more important.

The DECORANA plot shows a great degree of overlap between these samples and those that make up zone EB1C. The samples from zones EB1D and EB1E are also plotted close to these samples. All the samples from zones EB1B to EB1E are relatively similar, as reflected by the CONSLINK plot; therefore, as might be expected the differences between these zones are relatively subtle.

The arboreal and shrub pollen spectra for this zone are overall relatively stable. *Pinus* is less important than previously, averaging less than 1% T.P., *Quercus* falls from its peak at the end of zone EB1A to 16% T.P.

by the end of this zone.

The number of herbaceous taxa represented is higher than in the previous zone and both *Plantago lanceolata* and Liguliflorеae, the two commonest herbaceous pollen types after Gramineae, increase, reaching 4% and 5% T.P. respectively. The values of Gramineae increase further through this zone to reach 30% T.P..

Pteridium continues to increase, reaching a maximum of 11% near the top of the zone.

Zone EB1C. Depth 220-124cm.

The upper boundary of this zone, between samples 17 and 16 is again found to be significant by both SPLITLSQ and SPLITINF. The samples making up this zone also form a close, relatively distinct grouping on the CONSLINK plot.

Quercus is still the most numerous arboreal pollen type; its values are relatively stable averaging around 21% T.P.. *Alnus*, however is more variable, showing a range of values between 9% and 19% T.P.. A drop in the importance of *Fagus* is noticeable; it now averages less than 1% T.P..

Again there is an increase in number and levels of herbaceous types. Not including Gramineae; *Plantago lanceolata* and Liguliflorae are still the most important, averaging around 3% and 7% T.P. respectively. Amongst the most numerous of the other herbaceous taxa are *Ranunculus acris*, Crucifereae, *Bidens* type and Umbellifereae. The levels of Gramineae are stable but have fallen slightly, now averaging 17% T.P..

A drop is noticeable in the numbers of fern spores, values of both *Pteridium* and *Polypodium* have dropped to averages of 6% and 1.5% T.P. respectively. Filicales, however, remains at much the same values as previously.

Aquatic taxa are more numerous, *Sparganium* and *Potamogeton* both being present more frequently than in the previous zones.

Zone EB1D. Depth 124-77cm.

The upper boundary of this zone between samples 10 and 9 is once again found to be significant by both SPLITLSQ and SPLITINF, but both assign it relatively minor importance. This and the fact that both DECORANA and CONSLINK group these samples closely with those of zone EB1E reflects the two zones' mathematical similarity.

The numbers of arboreal and shrub pollen types are again stable, the values of *Quercus* and *Alnus* being slightly lower than in the previous zone, averaging 15% and 8% T.P. respectively. *Fraxinus* however occurs more frequently in this zone, but in very low numbers.

Although the number of herbaceous taxa represented in this zone is slightly lower, there is an increase in the average values of Liguliflоreae and *Plantago lanceolata* by around 1% T.P.. Gramineae, although again stable in this zone, is slightly more important with an average value of 23% T.P..

Pteridium values recover, and they now average at about 10%.

Potamogeton is markedly more important in this assemblage, reaching a peak of 12% T.P..

Zone EB1E. Depth 77-35cm.

Mathematically, the upper boundary of this zone, between samples 6 and 5 is important. Both SPLITLSQ and SPLITINF find this division to be the second most important in the whole diagram. CONSLINK also shows it to be one of the most significant.

The most notable features of the arboreal and shrub spectra are recoveries in the amounts of *Quercus* and *Pinus*, which increase to 27% and 3% T.P. respectively. *Fraxinus* has increased in importance, now averaging 1% T.P.. Values of *Alnus* and *Corylus* are stable in this zone but have fallen in importance, and they both now average less than 5% T.P..

In the herbaceous spectrum, *Plantago lanceolata* and Liguliflorae are seen to drop in importance; they both drop to values around 2% T.P. by the end of the zone. The amounts of Gramineae present however have increased slightly to give an average value of over 27% T.P..

Although still relatively frequent the levels of *Potamogeton* are lower in this zone , while *Typha latifolia* is now frequently recorded.

Zone EB1F. Depth 35-0cm.

The importance of the split between this and the previous zone is reflected in the DECORANA plot. These samples form a loose but distinct cluster, associated with higher axis 2 values than seen in any of the previous zones.

The increase in the values of arboreal taxa is possibly the most important feature of this zone. This is almost entirely due to the increase in *Alnus* which from a value of 13% T.P. at the start of the zone reaches 25% T.P. by its end. *Betula* is also seen to rise in importance, achieving values of over 5% T.P.. However, these increases are accompanied by lower *Quercus* values; although stable they now average 15% T.P.

The other major features of this zone are that *Plantago lanceolata* and Liguliflorеae are less important, both averaging less than 1% T.P.. The values of Gramineae, although more variable than before, increase overall and now average 31% T.P.. *Pteridium, Polypodium* and Filicales all fall away in importance, with none of these taxa achieving values much over 1% T.P..

Sparganium and *Typha latifolia* have both increased in importance, while there is a drop in open-water species.

9.2.5 Local Pollen Assemblage Zone Interpretation.

The size of the pollen catchment feeding this site will be fairly limited. The size and shape of the pond suggests that most of the pollen reaching it directly from the air will be predominantly of local origin with only a relatively minor component of more regionally derived pollen. As previously mentioned the pond is stream fed, but as the streams feeding the pond rise close to the site (see Fig. 2.1), they will also supply pollen of predominantly local origin.

In the absence of ^{14}C analysis it is difficult to estimate the age of the sediments in the pond. The historical records show the maximum age possible for the start of the diagram is 16th century. The possibility that the pond may have been dug out at some point since this time, which would mean the sediments could be younger must always be considered. However, there is no obvious major break either in the stratigraphy of the pond's sediments or pollen content, so this possibility can be disregarded with some confidence. As mentioned in earlier chapters, the *Pinus* curve could throw some light on the chronology of the sediments, as it has only been planted in the South East of England since the latter part of the 18th century. The constant presence of low numbers of *Pinus* in the first assemblage zone would therefore at first suggest that the sediments in fact are of relatively recent date.

However, the shape of the *Pinus* curve, dropping in importance at the beginning of zone EB1B, and records of bisaccate pollen types other than *Pinus* in this assemblage prompted further investigation of these pollen types. Thus, it was decided to investigate the state of preservation of the *Pinus* and other bisaccate pollen grains from this core. The following classification, a simplified version of those used by Cushing (1967), Birks (1970) and Lowe (1982) was used in this study:

1. Well preserved- grains that show no sign of

degradation.

2. Corroded- grains whose exines show signs of etching or pitting.

3. Broken- grains whose exines have been broken.

4. Degraded- grains that appear to have undergone a structural rearrangement so that structural elements appear to be vague or diffuse.

The results of this study are given in Fig. 9.7. It can be seen from these results that the majority of the grains in EB1A are of the degraded type. This could be interpreted in a number of ways, either the degradation is a function of age, as suggested by Hill (1981), and would therefore be expected to be more prevalent in the lower sediments, or degradation is related to sediment type, or that degradation is due to mechanical damage possibly caused by reworking of sediments (Birks, 1970).

The presence of pre-Quaternary spores in the assemblage shows that some reworked elements are definitely present in this assemblage. Some of the bisaccate pollen grains also appear to be of types of pre-Quaternary origin. It is possible that the poor state of preservation of other grains may have caused many such grains to be missidentified as *Pinus*. If many of the bisaccate grains are in fact reworked, it might be expected that their occurrence correlates with that of the pre-Quaternary spores. Fig. 9.7 also gives a histogram of the records of pre-Quaternary spores. It can be seen that the shape of this graph shows some similarity to those of the degraded class of the bisaccate pollen types. Whether

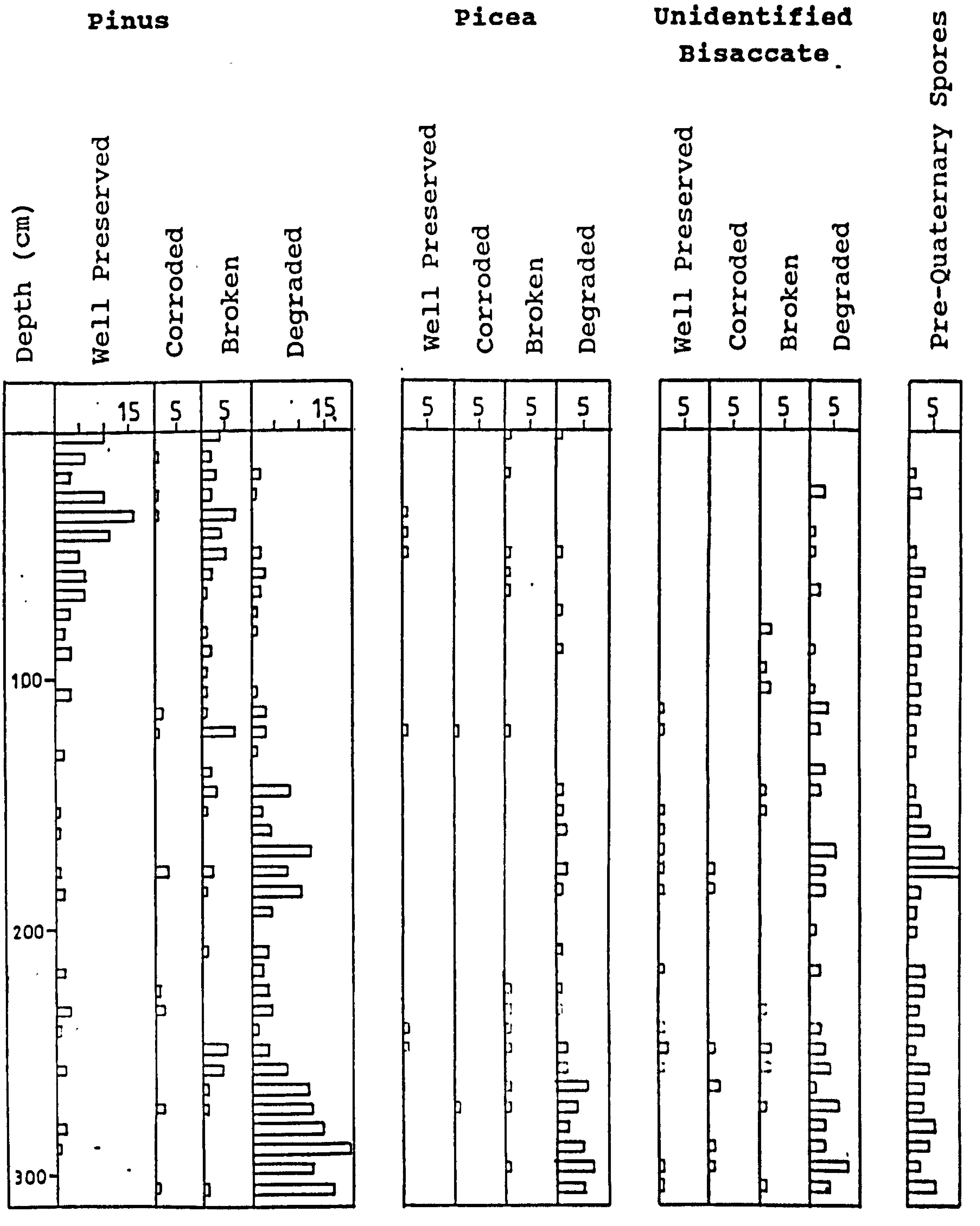


Fig. 9.7 EB1-Analysis of Bissacate Grains and Pre-Quaternary Spores

(Values expressed as number of grains/spores per 500 pollen grains.)

there was any significant correlation between the numbers of pre-Quaternary spores and degraded bisaccate grains was investigated using regression analysis, using a statistical software package running on a BBC microcomputer. The analysis gave a coefficient of determination of 0.313, which shows the correlation is significant. As a control, the relationship between the non-Quaternary spores and all of the bisaccate grains noted was also investigated. This gave a coefficient of determination of 0.064 which is below the level of significance. However, as numbers of bisaccate pollen and pre-Quaternary spores noted are small, some caution must be expressed on the accuracy of these statistical tests; ideally a larger sample size should have been used.

Zone EB1A.

The study of bisaccate pollen outlined above may have a number of implications in the interpration of this pollen assemblage zone. Firstly, if many of the bisaccate grains are reworked, the abundance of *Pinus* in this region is less than might be at first assumed. Secondly, the age of the sediments may be greater than that indicated by higher values of *Pinus*. And thirdly, peaks in the degraded bisaccate grain and pre-Quaternary spore histograms may indicate periods of high sediment erosion into the pond.

If the numbers of degraded bisaccate and non-Quaternary grains in this assemblage zone indicate erosion, any such erosion appears to be highest at the beginning of the zone, declining towards its end. The percentages of Filicales spores, another possible indicator of soil erosion, show a similar pattern. It is possible that erosion is linked to coppicing. The removal of the tree canopy, inherent in such management, increases water movement over and through soil (Moore, 1985). This will enhance the loss of any unstable soils.

The high numbers of *Corylus* pollen at the start of the zone could indicate coppice management (see Appendix 1) in the area. As well as the furnace, a limekilm and brickworks were also present on Ebernoe common. It would be most economic for the fuel for these industries to be produced locally. Coppiced woodland would be the most likely source (Yates, 1988).

The fall in the importance of *Corylus* and the increase in the values of *Quercus* suggest that there was a change in the management of coppice in the area. It is possible that either some areas of coppice were abandoned or that *Corylus* was replaced as the commonest underwood species by another species such as *Quercus*.

Although *Quercus* is almost certainly the most numerous tree in the area, the amounts of *Fagus* pollen recorded (if its low pollen representation is taken into account) show that this tree must also have been common.

Alnus pollen is numerically important, which is probably merely a reflection of the presence of this tree in the wetter parts of the locality, such as at pondside, stream bank and spring line locations. However, as it is seen to decrease in importance, it is either being felled and/or it is possible that areas of carr are being drained.

Despite relatively low values of Gramineae at the start of the zone, it is very unlikely that much of the area making up the pollen catchment area is wooded. A number of pollen types recorded can be regarded as indicators of pastoral activity. The importance of *Plantago lanceolata*, and records of *Ranunculus acris* type and *Centaurea nigra* type pollen indicates that there could be open meadows locally. Possible indicators of wood-pasture include *Calluna*, *Pteridium*, *Polypodium*, Umbelliferae, *Artemisia* (Behre, 1981) and *Ilex* (Moore, Evans and Chater, 1986). Records of Liguliflorae, *Polygonum aviculare*, Cruciferae and *Plantago media/major* type could also indicate wood-pasture. Such evidence for this scheme of woodland management is consistent with the historical documentation.

If, as seems to be the case, Ebenoe Common was at least partially managed as wood-pasture, it would have implications for how other features would be managed. Any areas of coppice present around the common would have to be enclosed, at least in the early stages of the coppice cycle, to prevent damage to the young tree shoots through grazing (Peterken, 1981).

There is little srong evidence to suggest arable activity. The possible cereal grains and the records of *Cannabis*- type pollen could indicate the presence of actual crop plants, while *Rumex obtusifolius* is a possible arable weed.

Zone EB1B.

Quercus and *Fagus* both still appear to be important, but it seems that they were declining in number. The increase in *Betula* pollen suggests that there could have been an increase in rather disturbed ground, which this tree is able to invade. It could also be a reflection of a decrease in the areas of coppice, as this tree often invades abandoned coppice (Rackham, 1980). *Pinus* is less important in this assemblage zone, which could be an indication that there has been a degree of clearance of this tree, assuming it had been formerly present. However, it may indicate a drop in erosional activity in the catchment, if these grains are reworked from older deposits.

The increases in *Plantago lanceolata* and Liguliflorae pollen suggests that there has been an increase in pastoral activity in the area, whilst the increase in Gramineae suggests that the area could be becoming more open. This would suggest that the fall in importance of *Quercus* and *Fagus* might be due to the felling of some of these trees. However, it cannot be ruled out that an increase in grazing in the local wood-pasture system has opened out the local woodland by reducing the ability for trees to regenerate. The increase in values of *Pteridium* spores and the slight increase in *Calluna* pollen add weight to this hypothesis.

There is stronger evidence for arable activity, possible cereal grains being recorded from every level in the zone and there is a record of *Fagopyrum* pollen. Many other pollen types that may represent arable weeds, such as *Rumex acetosella* and *Polygonum aviculare*, are also recorded.

The record of *Drosera intermedia* pollen and the frequent occurrence of *Sphagnum* spores in the diagram as a whole, indicate that there were wet, boggy conditons in the area.

Zone EB1C.

The generally uniform nature of this assemblage zone suggests that a period of stability is recorded. On the other hand, the investigation into non-Quaternary spore and bisaccate pollen grains suggests that this assemblage zone coincides with a period of increased erosional activity in the catchment. It is possible that the streams feeding the pond, eroded material directly from the Weald Clay. An increase in surface water runoff, possibly due to a reduction in tree cover, could be responsible for this.. Such a loss, indicated in the previous zone, could increase stream flow and therefore also increase the amounts of reworked material entering the pond.

The numbers of *Quercus* and *Fagus* pollen grains present throughout this assemblage zone are similar to those seen at the end of the previous zone. This suggests that a balance between the arboreal and grazing elements of the wood-pasture system has been reached. However, the pollen of *Acer*, a tree species present at the site today, is recorded for the first time in this assemblage zone.

The summary pollen diagram (Fig. 9.3) shows that the overall amounts of herb and grass pollen are higher in this zone. The possiblity of both arable and pastoral activity is still apparent in the herbaceous pollen spectrum. The records of *Melampyrum* are of note, for this is a pollen type that is strongly associated with wood-pasture (Behre, 1981). Increases in Liguliflorae, Umbelliferae and *Artemisia* could also indicate the importance of wood-pasture.

The decrease seen in *Pteridium* is not what might be expected as this species is strongly associated with wood-pasture (Behre,1981). Possible reasons for its decrease could be an increase in trampling or in the cutting of the species for fuel and cattle bedding, a practice known to have taken place in the region (Yates, 1988). It is of note that *Pteridium* was formerly used in brickmaking (Rackham, 1986), an activity that has been documented on the common.

Not all forested parts of the area are managed as wood pasture. Records of pollen types such as *Anemone* and *Mercurialis* can be interpreted as showing the presence of closed canopy woodland. The continued presence of *Corylus* possibly indicates the presence of coppice.

Records of *Fagopyrum*, *Cannabis* and *Solanum nigrum* could represent arable agriculture.

Zone EB1D.

Although the overall similarity between this and the previous zone suggests that the same range of vegetation types outlined previously are represented, the increase in numbers of herbaceous pollen types and decrease in arboreal grains suggest that there has been a change in the proportions of the different land uses.

The rise in the values of Liguliflorae are the most noticeable change, which, together with the increase in *Plantago lanceolata*, *Pteridium* and Gramineae seen, could indicate an increased importance of pastoral activity, possibly in the form of both wood-pasture and more open conditions. Corresponding drops in *Corylus* and *Quercus* pollen, although small, suggest that it is areas containing these species that have declined. This combination of pollen types suggests that an area of coppice with standards could have been lost.

Zone EB1E.

Although numerically relatively small, the changes seen between this and EB1D could represent an important change in the management of the area. The increase in *Pinus* is of note. Not only has the frequency of this pollen type increased, but the analysis of its state of preservation also shows a marked change. There is an increase in the number of well preserved and broken grains (see Fig. 9.7). These pollen grains are almost certainly contemporaneous with the pollen spectrum as a whole, rather than reworked, and indicate the planting of this tree in the area. However, the numbers of *Pinus* pollen present are relatively low and therefore show that pine is not common locally.

There is a marked drop in the numbers of Gramineae and herbaceous pollen types together with an increase in the amounts of *Quercus* pollen, which suggests that there has been a decline in the levels of grazing pressure in areas of wood-pasture. The increase in the amounts of *Quercus* pollen is a direct consequence of such a drop in grazing, as the tree would be able to regenerate more freely. *Fraxinus* and *Fagus* also appear to increase at this point, but were relatively minor components in the local woodland. However, it is known that a limited amount of grazing did continue on Ebernoe common itself upto the 1960's (Yates, 1988).

Zone EB1F.

This assemblage zone obviously brings the story of the local vegetation up to the present-day vegetation types. The main feature is apparently a continued decline in grazing pressure. Numbers of possible pastoral indicators such as *Plantago lanceolata*, *Calluna* and Liguliflorae are at their lowest in this assemblage. The numbers of most herbaceous pollen types, other than Gramineae, are in fact very low. This could indicate a change in the structure of ground-level vegetation; a drop in grazing could allow grasses to increase markedly in height, thus shading out other competing species.

The increase in *Betula* could also be a reflection of a drop in grazing pressure. Areas formerly open if left alone would be liable to invasion by this pioneer species.

Numerically the most obvious feature of this zone is the increase in *Alnus*. Today, alder carr is confined to the area around this pond and the streams feeding them, so it must be assumed this is the source of the pollen. The increase in *Alnus* suggests that either the drop in grazing is allowing the carr habitats to expand, or that *Alnus* in the area had been subjected to a management scheme, possibly such as regular coppicing, that had decreased its overall pollen output in the past.

As would be expected from the vegetation of the common today, other arboreal types are well represented.

9.3 Summary.

Apart from those in the first assemblage zone (EB1A), the changes seen throughout the diagram are relatively subtle reflecting fluctuations in the importance of different land uses rather than more wholesale change. Evidence from early 19th Century maps (Yates, 1988), shows that the areas of woodland, common and farmland have changed little during the last 200 years, and the general stability of this diagram suggests that these areas have remained much the same size since the late Medieval/Elizabethan period.

Documentary evidence for the practice of wood pasture on the area of common land near the pond is rather extensive (Peterken, 1981; Yates, 1988). Cattle, formerly referred to as Rother Beasts, were the the main animals grazed on the site, but, pigs and sheep are also mentioned with reference to this site (Yates,1988). The presence of a warren is shown on the map of 1829 which suggests that grazing by rabbits could also have been important in the past.

Evidence from pollen diagrams for this wood-pasture vegetation type, often referred to as Hudewald, will always be inconclusive due to the problem that pollen grains are often only identifiable to a crude taxonomic level. This means that one pollen type may include a wide range of species, that could represent a number of different habitats. Also, even if a pollen grain is identifiable to species level, the species may grow in a wide range of situations (Moore, 1980). However, many of the pollen types associated by Behre (1981) with wood pasture are present in this diagram, and this, coupled with the documentary evidence, confirms the presence of this vegetation type. Evidence for the existence of wood pasture is present from the start of the diagram but, as might be expected, it appears to decline in importance in the last two assemblage zones.

Speculation on the timespans covered by the assemblage zones is, at best, very crude. Firstly, no exact date for the building of the pond is available; the most accurate date that the documentary evidence can offer is that the pond was built sometime in the 16th century (Yates, 1988). Secondly, it would be unwise to assume that the accumulation rate of the pond's sediments was uniform. The fact that there appear to have been periods when erosion in the catchment was greater than at other times, suggests that the amount of sediment entering the pond would vary accordingly.

Although the proximity of Ebenoe Common to the pond suggests that this area is an important source of pollen entering the pond, it will not be the only area whose vegetation is represented in the assemblage. Woodland and some arable habitats are also represented in the diagram.

The presence of limekilms, brickworks and ironworks on Ebenoe Common during its history suggests that the production of fuel must have been important in the area. There is evidence that a certain amount of fuel was produced on the Common itself. Some trees present at the site today have been pollarded in the past (Yates, 1988). This practice is impossible to detect in pollen diagrams as the species involved are common woodland trees such as *Quercus* and *Fagus*, and obviously it is impossible to distinguish between pollen from a pollarded individual and that from a standard woodland tree. Coppice woodland is likely to have been the main source of fuel in the area, the pollen evidence for which is discussed earlier. Although there is no coppice on Ebenoe Common itself, coppices such as Brickiln Rough are present around the Common today.

Documentary evidence suggests that none of the trees present on the Common are more than 200 years old (Yates,1988). During the late 18th/early 19th centuries there was a dispute (initiated by timber felling) between the then lords of the manor, the Peachy family and the neighbouring Leconfield Estate concerning the boundaries of the two estates. It would seem that many of the timber trees present on Ebenoe Common were felled between 1780-90, possibly to help finance the building of Ebenoe House in 1786. Little evidence of such a clearance is apparent in this pollen diagram, which implies that the trees on Ebenoe common only accounted for a small proportion of the total woodland in the pollen catchment area of the pond. Also, although woodland has apparently increased on the Common since the decline in grazing, which has led to its rather overgrown state today (Yates,1988), this change in land use is represented in the pollen diagram by a reduction in pastoral weeds rather than an increase in many of the arboreal pollen types.

CHAPTER 10 - DISCUSSION AND CONCLUSIONS

10.1 Sources of evidence.

Through the course of this study the palynological evidence was gathered from a number of different sediment types, namely lacustrine muds, peats, mor humus and soil. The major sources of information were the hammer ponds and it will be the discussion of the results from these sites that will form the bulk of this chapter. The pollen diagrams produced from the other sediment types were primarily produced to supplement the information from the hammer ponds. However, the cores taken from the Burton Mill Pond site not only provide information from a wider timespan than that covered by the lacustrine cores, but they also illustrate that pollen diagrams produced from different sediment types from the same area can all give the same basic vegetation history, with each diagram highlighting different aspects of the past vegetation.

Evidence from historical records proved to be most valuable for Combe pond and Ebenoe Pond. However, it was also possible to gain some information about the age of some of the other sites from such records.

10.2 Time period covered by the hammer ponds

Of the hammer ponds investigated in this study, Burton Mill Pond appears to have been built before the others, probably sometime in the 13-14th century. This early date suggests that it was not originally associated with the iron industry. Possibly, it was built in conjunction with the fishery and mill mentioned as being present at the site in the Domesday book. However, it appears that the pond was extended to its present size around 1620 (±65 years). This date is consistent with the pond being extended in conjunction with the building of the iron works at the site. Historical and ^{14}C evidence points to the fact that Combe Pond, Ebenoe and Hammer Pond were all built in the 16th century. The diagram from Furnace Pond is more problematical; although historical records suggest it was built in the mid 18th century, there is some evidence that the pond could have been dug out once again in the early part of this century.

Ascertaining whether the sediments from any one of the ponds had been disturbed is obviously an important question. Features that might indicate such an event would include the occurrence of a change in sediment type accompanied by a sudden change in the pollen assemblage. However, changes within the catchment area of a pond, such as large-scale deforestation could also cause such a change. Therefore the cause of such features have to be carefully considered. In this study, with the exception of Furnace Wood Pond, mentioned above, it appears safe to assume that such disturbances did not take place. The sediments from the Burton Mill Pond cores are well supported with ^{14}C dating which does not reveal any evidence of such breaks. The sediments from Hammer Pond and Ebenoe Pond are relatively uniform throughout, and no drastic changes are seen in their pollen stratigraphies. The change in sediment type, associated with the decline in *Corylus* and establishment of heath seen at Combe Pond could suggest a break in the sediments, but historical records are consistent with such a change happening at this point in the diagram.

As hoped, the relatively fast sedimentation rate seen in these ponds (Hammer Pond and Ebenoe Pond possibly being the best examples, where around 3 metres of sediments have collected in around 400 years) provided the oportunity to examine the vegetational history with quite a high degree of temporal precision. At some of the sites investigated the 4cm gap between samples is likely to represent a timespan of less than 10 years. (A wider sampling interval was used at Ebenoe simply because of time constraints.) However, because of the inherent mixing of sediments within a lacustrine system (Davis,1968), there is likely to be a limitation on the temporal accuracy possible through the use of smaller sampling intervals. It is possible further accuracy could be gained if the sedimentation rate throughout the history of each pond could be ascertained, though there are serious problems associated with this (see section 10.7).

10.3 Conditions when the hammer ponds were formed.

If the vegetation represented by the pollen assemblages of the earliest sediments from all of the hammer ponds are compared, it can be seen that there is a significant difference between the ponds located on the Lower Greensand formation and those found on the Weald Clay. It is a feature of the pollen diagrams from the ponds on the Lower Greensand (Burton Mill Pond and Hammer Pond near Iping) that there is evidence for the former presence of heathland. There is strong evidence that Burton Mill Pond was originally built on an area of heathland. The supplementary peat and soil/mor humus cores from Burton Mill and the small peat core from Black Moss again show the importance of this vegetation type on the Lower Greensand.

Calluna-dominated heathland is a relatively important vegetation type on the Lower Greensand formation today, and is most commonly present on the outcrops of the Hythe Beds and the Folkestone Beds. Examples of heaths present within the area covered by this study include Iping Common and Woolbedding Common. Outside the area of study, important examples of heaths include Hindhead Common on the western part of the Lower Greensand outcrop and Thursley and Hothfield Commons in the northern part of the outcrop. The pollen diagrams from Burton Mill Pond and Hammer Pond indicate that the extent of heathland on this geological outcrop was formerly far greater than at present. This evidence is similar to that found by Moseley (1987).A number of sites studied by him on the northern part of the Lower Greensand ridge, namely Leith Hill in Surrey together with Brasted Chart and Styants Bottom both in Kent and currently wooded, give evidence showing that they all formerly carried heathland.

A degree of grazing pressure would have been necessary to keep the heaths open. Evidence from the Burton Mill Pond valley mire core (BMP3), supplemented with evidence from ^{14}C analysis, showed that this vegetation type first became established at this site in the middle to late Bronze Age. As mentioned previously this is consistent with the view that many such heaths date from this period (Dimbleby, 1962), and with the studies of other sites in the area by Scaife (in Drewett, 1985), Scaife and Macphail (1983) and Keating (1983)(see Fig. 4.31). However, it would be unwise to assume from this that all the areas of heathland present on the Lower Greensand date from this period. Moseley (1987) suggested that it was possible the heathlands he studied could have originally formed in Anglo-Saxon times and expanded in size during the Middle ages. Although it was not possible to support this theory with evidence from ^{14}C analysis, a comparison is drawn with the Anglo-Saxon clearance episode seen at Epping Forest, Essex (Baker et al., 1978).

None of the pollen diagrams from the ponds on the Weald Clay show any evidence of heathland being present in their vicinity when they were built. However, the diagram from Combe Pond, near Rogate, does show that an area of heath did become established in the vicinity of this pond at a later date.

The presence of alder carr is seen at all the sites, but this might be expected as, by definition, the ponds will be associated with wet conditions.

It is clear from all the sites that before the ponds had been built a mixture of vegetation types had already become established in the area. Evidence for woodland, both closed canopy and coppice, wood-pasture, open pasture and some arable sytems are all seen. In most of the study area the woodland is dominated by *Quercus*, but in the vicinity of Burton Mill *Fagus* is also important. The fact that *Fagus* is more numerous here is possibly a reflection of its importance on the calcareous soils of the nearby chalk escarpment.

Combe Pond can be seen to form an exception to this general picture. There is evidence that suggests there was significant modification of the local vegetation around the time that the pond was built. Numbers of arboreal pollen are lower than seen at other sites, and the assemblage is dominated by *Corylus* (suggesting the presence of large areas of coppice). Historical sources suggest that many timber trees were felled here when the pond was constructed, but the evidence of this in the pollen diagram is limited.

10.4 Pre-heathland Vegetation.

The valley mire core taken at Burton Mill (BMP3) provides evidence of the nature of the vegetation that preceded the heath at this site. The pollen assemblage from the base of this core shows the presence of deciduous woodland, possibly rather open in nature. *Alnus* appears to have been dominant in the wetter parts of the valley bottom, while on the drier slopes woodland rich in *Tilia* and *Quercus*, together with significant amounts of *Corylus*, was present. Because *Tilia* pollen shows poor dispersal and is badly represented in pollen diagrams it is possible that this tree was the most important of the forest trees. The open nature of the woodland may have been due to anthropogenic activity in the Mesolithic period, being kept open by a degree of grazing. Again the presence of this open woodland can be seen as being consistent with the soil pollen diagrams from West Heath (Scaife, in Drewett, 1985; Scaife and Macphail, 1983) and Iping Common (Keating, 1983).

A parallel of this result can also be found on the northern section of the Lower Greensand ridge, where Moseley (1988) in his investigation of Hothfield Common showed that the heath at this site was formed following a gradual clearance of *Tilia*-rich woodland. Unfortunately his pollen diagram from this site has no ^{14}C dates associated with it. The clearance of *Tilia*-rich woodland followed by the formation of heath has also been recorded at Hampstead Heath, London (Girling and Greig, 1977) and Epping Forest, Essex (Baker et al., 1978).

The presence of woodland rich in *Tilia* and its subsequent loss seen at Burton Mill, supports the hypothesis that the decline in *Tilia* seen in many British pollen diagrams was due to human activity (Turner, 1962).

10.5 Loss of Heathland.

The loss of heathland seen in the pollen diagrams from Burton Mill, Hammer Pond, Iping and Combe Pond, Rogate coupled with the subsequent re-afforestation of the land shows that within the time period covered by the hammer ponds, there has been an increase in woodland cover rather than a decrease. ^{14}C analysis was carried out on sediments documenting the loss of the heathland at Burton Mill, but the results fell within the 'modern' period. Therefore, it is impossible to give an exact date for the loss of heath, but a date sometime in the 19th century would seem to be the most likely. The loss of the heaths seen at Hammer Pond and Combe Pond have no ^{14}C dates associated with them, so it is only possible to speculate as to when they were lost. It seems reasonable to assume that at Combe Pond the re-afforestation occurred at much the same time as that seen at Burton Mill, however, the fact that this vegetation change occurs relatively early in the Hammer Pond diagram suggests that it could significantly predate the loss of heathland seen at the other sites (if the assumption is made that the sedimentation rate at Hammer Pond was constant, the loss could have happened as early as the mid 17th century).

At all three sites the loss of the heathland is followed by increases in *Betula* and *Pinus* pollen, and, in the case of Combe Pond and the mor humus diagram from Burton Mill, an increase in *Quercus* is also seen. It would therefore seem that the loss of heathland was brought about either by trees being planted on freshly enclosed heaths, or through a decline in grazing which would allow these trees to become established. *Pinus* and *Quercus* are the tree species most likely to be planted; however, it is possible that at Hammer Pond *Betula* was activily encouraged, since this tree was often used to produce charcoal to fuel the iron industry. (The early loss of heath seen at Hammer Pond could have occurred during the period when the ironworks were active at the site). Alternatively, it may have been a decline in pastoralism that caused the reversion of heathland to forest, perhaps related to the drop in rural populations seen in the 19th century as people moved to towns with the acceleration of the industrial revolution. Moseley (1987, Moseley and Moore, 1988) found that a similar sequence of vegetation changes had occurred in the northen part of the Weald. He found that the loss of heathland at the sites studied by him occurred between 1750 to 1850, which is consistent with the results fom Burton Mill and Combe Pond.

10.6 Evidence for deforestation.

Although all of these sites were associated with the iron industry (Ebernoe, Furnace Wood Pond, Combe Pond were all associated with furnaces; Burton Mill, Hammer Pond associated with forges - Straker, 1931), the pollen diagrams obtained from them show that, on the whole, there is no evidence of large-scale deforestation in the area studied. In fact the values of arboreal pollen types are seen to remain relatively constant, or even increase, through the time periods covered by the hammer ponds.

However, as mentioned previously, Combe Pond can be seen as an exception to this story. The pollen diagram together with historical records (Yates, 1972) suggest that many timber trees could have been felled during the time the pond was constructed and that coppice management became important in the area. But it can be seen the coppice was later lost, apparently due to a local demand for common grazing land, and it was replaced by heath. Although Combe Pond occurs on the Weald Clay, in the area of the pond there are substantial outcrops of the sandstone that sometimes occurs in the Weald Clay. This deposit provided soil conditions more suitable for the development of heathland than those of the Weald Clay proper.

The evidence from the pollen analysis therefore supports the view that the fuel for the iron industry was generally provided by renewable sources such as coppice management (a discussion of woodland management is given in section 10.7.). The theory that the iron industry was responsible for the deforestation of large tracts of the Wealden District, therefore, appears to be largely unfounded, at least in this area of the Weald.

The records of pollen types indicative of both pastoral and arable agriculture, that are seen in all of the pollen diagrams, imply that there had been a degree of woodland clearance to provide land for agricultural use before the hammer ponds were built.

In the case of the sites on the Lower Greensand, heathland appears to have provided a significant proportion of the pasture. As mentioned previously the heath in this area could date from episodes of deforestation as early as the middle Bronze Age.

Pastoral activity was not restricted to the areas of heath: indicators of both open pasture and wood-pasture are seen in the diagrams. In the case of the Weald Clay sites, most notably at Ebenoe, these land uses appear to be important activities. The diagrams from Burton Mill and Hammer Pond, Iping, suggest that these activities persisted after the loss of heathland. Unfortunately the pollen diagrams cannot shed any light on when these activities commenced in the area. Historical records suggest that parts of the Weald were used for swine pasture since the Dark Ages. In the area of study there is some evidence of swine pasture in the vicinity of Ebenoe from an early 15th century document (Yates, 1988). The pollen assemblage at the base of the Burton Mill valley mire core shows that wood-pasture could have been taking place in this study area since the Bronze Age. Such a finding is reasonable since it has been shown in some pollen studies that wood-pasture was practi ed as far back as the Neolithic (Pott, 1989).

10.7 Woodland Management.

It is apparent from the pollen diagrams that areas of closed woodland, coppice and wood-pasture were all present in the area during the period studied.

As discussed in earlier chapters, it is very difficult to obtain conclusive evidence of coppicing from pollen diagrams. However, it may be possible to improve detection of coppice management in a number of ways. In cases where there are apparent regular fluctuations in the percentages of species such as *Corylus* and *Alnus*, as seen in the pollen diagram from Hammer Pond, Chithurst, absolute pollen counts could prove valuable in determining whether the fluctuations represent real events or are statistical artifacts of the pollen sum. However this technique requires an accurate assessment of the sedimentation rate in order that the pollen influx rate can be worked out. In the case of recent sites such as those investigated here, with relatively deep sediments, this could prove problematical. The inaccuracies associated with ^{14}C analysis, especially within this recent time period, would mean the method of dating is likely to prove inadequate. ^{210}Pb dating may be more suitable, but ideally evidence of annual laminations within the sediments would be required to give an accurate indication of the sedimentation rate.

In the case of assemblages where no such evidence of regular fluctuations is seen (this is likely to be the most common state of affairs, as an area of coppice managed rotationally is likely to have a constant pollen output - see Appendix 1), it may be possible to gather evidence for coppicing by looking for the pollen of herbaceous species that are associated with coppice. Coppicing has a number of well documented effects on the ground flora of the woodland concerned (Rackham, 1980; Peterken, 1981), usually because of the increase in light levels that is a consequence of coppicing. The most marked effect is the increase in the flowering of spring flowers such as *Viola riviniana*, *Hyacinthoides non-scripta*, *Glechoma hederacea*, *Primula vulgaris* and *Geum rivale*. The effect is most strongly seen in the second year after coppicing but the level of flowering falls back after a further year or two. Species that may be already present in a woodland, but do not normally flower, may flower or produce spores after coppicing. Examples of plants that show this behaviour include: *Filipendula ulmaria*, *Carex riparia* and *Pteridium aquilinum*. The seeds of light-demanding species that will normally lie dormant in the woodland soils, such as *Juncus* spp., *Euphorbia amygdaloides*, *Rubus idaeus*, *Chenopodium polyspermum*, *Centaurium erythraea*, *Malva moschata*, *Hypericum humifusum*, *Lythrum salicarica*, *Isolepis setacea* and *Holcus mollis*, will often germinate after coppicing. Other groups of plants that are associated with coppice include species that will disperse through woods, for example, between glades and newly coppiced areas. These include *Cirsium palustre*, *Epilobium hirsutum*, and *Chamaenerion angustifolium*. Also casual species from outside the wood such as *Cirsium arvense* and *Picris echioides* may also become established in newly coppiced areas. Although all the above species are seen to increase their level of flowering, some shade tolerant species such as *Mercurialis perennis*, *Allium ursinum* and *Paris quadrifolia* are seen to decline after coppicing (Rackham, 1980; Peterken, 1981).

Although this account suggests that records of such species in a pollen diagram could indicate the presence of coppice, a number of problems will be associated with the use of these pollen types as indicators of this type of woodland management. Many of these plants utilise entomophilous pollination, which tends to mean pollen production is relatively low and its dispersal into sediments suitable for study will be rather limited. Therefore, if one is hoping to find significant numbers of pollen grains from these species, very large pollen counts may have to be undertaken. Another major problem is the limitations of pollen identification (Moore, 1980). Determination of some pollen types will only be possible to low family or generic levels, and such pollen "types" could include species that do not grow in this type of woodland. Even when identification is possible to species level, the species could be present in a number of different habitats. Also, many of the species mentioned, such as *Geum rivale* and *Hyacinthoides non-scripta*, are present and flowering, in non-coppiced woodland. This again means that the use of these pollen types as definite coppice indicators will be limited in value.

It can be concluded that although it should be possible to detect a change in woodland management from a closed canopy system to a coppiced system from a change in the overall pollen rain, it is more difficult to identify coppice that has been present since before the start of a pollen diagram.

One species of tree, *Pinus*, is of particular interest as it presence is likely to be largely due to it being planted in the area. This is of use as a temporal indicator, especially in diagrams such as Combe Pond when it first appearance in significant numbers can be seen. Historical sources such as the Board of Agriculture Reports 1790-1813 (Jones, 1961) suggest that plantations first became important in the region in the mid 18th century (especially on areas of recently enclosed heaths). A timber shortage had been initiated during the Seven Years War (1756-63), which led to plantations being actively encouraged. One successful scheme to promote plantation was initiated by The Royal Society of Arts which awarded medals for the largest plantations of each year (Holmes, 1975), a practice which contiued until 1821. Although *Quercus* was possibly the most numerous tree planted, the conditions offered by the southern heaths would be particularly suitable for *Pinus*.

10.8 Agriculture.

Other than forestry it can be seen that both pastoral and arable activity is indicated in the pollen diagrams. The pollen evidence for pastoral activity is the strongest, but it appears that it has been declining in importance in the more recent past. Not only is the disappearance of heath (seen at Burton Mill, Hammer Pond and Combe Pond) and the neglect of wood-pasture (apparent at Ebenoe) seen, but indicators of open pasture such as *Plantago lanceolata* are also seen to drop in number.

Evidence of crop plants is less strong, arable agriculture often being best represented by the presence of the pollen of weed species such as *Papaver* and *Centaurea cyanus*. Records of the pollen of actual crop plants are relatively infrequent, apart from the presence of possible cereal pollen. The commonest pollen of crops noted were *Fagopyrum* (buckwheat) and *Cannabis* type (which could indicate either hops or hemp).

There are historical records of some arable land being held in common within the area of study (Yates, 1988). The so called "fielden" districts were medieval examples of this practice, being normally found close to the Downs. An example of one of these districts is Duncton, near Burton Mill. It is therefore possible that the arable activity indicated in the pollen diagrams from this site represents this area.

10.9 Suggestions for Further Work.

Ideally the vegetation history of an area should be investigated through open sites such as lakes and large peat bogs (Berglund, 1979), but such sites that offer long, undisturbed, sediment sequences are unavailable in the Wealden District; this study shows that it could be possible to build up a more complete picture of the region's vegetation history by the investigation of more 'fragmentary' deposits. In fact the small hammer ponds, shallow peat deposits and mor humus deposits provide a detailed picture of vegetation history in an area containing many different vegetation types

In the central and eastern parts of the Weald the iron industry became established much earlier than was the case in this area. There are a number of sites that were established by the Romans, or even earlier (Straker, 1931). A study of a number of these sites associated with a wider geographical and temporal spread, than seen in this study, would obviously give a more comprehensive picture of the effects of the iron industry. It would be unsafe to assume that although the effects on the vegetation of the relatively recent iron works investigated here, were relatively benign, the same would follow for older sites. It is possible that the fuel and practices used in earlier times were different from those used in the later stages of the industry. It should be noted that Straker (1931) provides some evidence that suggests that the size of the charcoal pieces used for fuel at some of the earlier furnaces was significantly larger than that used in the more recent furnaces. It appears that large timber trees could have been used as fuel. Whether derived from the clear felling of the forest or from trees felled in the creation of a coppice system, would be a point of interest.

To gain a better understanding of the past vegetation of the study area, (and of the Weald in general) a number of comparative studies of contemporary pollen would be valuable. Surface pollen studies within an area of coppice would provide a better understanding of the pollen rain from this woodland type. Ideally such a study would be carried out throughout the whole of a coppice cycle. However, the results of such a study would only be usefully applicable to pollen diagrams produced from terrestrial sites.

Of possibly more relevance to a study such as this is the positioning of pollen traps in streams in the area which could produce a better understanding of the recruitment of pollen into the sediments of the hammer ponds. Comparison with pollen contained in the seston of the main body of the lake, could also give information on the importance of aerial deposition of pollen into such a system. A repeat of the type of studies carried out by Davis (1968) applied to the resuspension of sediments in small lakes such as the hammer ponds would give a better understanding of the temporal definition possible from these sediments.

It would also be useful to determine whether a single core from a hammer pond is actually representative of the whole basin, or whether there is a degree of variation caused by depositional differences within the lake basin. This could be simply investigated by taking a second core (or even a greater number) for a comparative study. Such a second core was taken from Ebenoe pond, but its analysis was not carried out because of time constraints.

This project has opened up new possibilities for the reconstruction of vegetation history in the Weald during historic times and it is hoped that these preliminary investigations will lead to the development of further research in the area.

APPENDIX 1- *Corylus* pollen production and the effects of coppicing.

Pollen representation of *Corylus* depends upon the position in which the shrub is growing and especially the structure of the canopy layer. These factors have implications for both pollen productivity and dispersal, and hence the interpretation of fossil pollen assemblages. Models for the processes governing *Corylus* pollen production and dispersal are given below for situations where *Corylus* is either a part of high forest or of a coppice-with-standards management system.

1. *Corylus* in high forest

a. *Corylus* in the shrub layer.

Today *Corylus* is commonly found as an understory in British *Quercus* and *Fraxinus* woodlands. However whether it was as common in this role in undisturbed high forest may be called into doubt as many of the semi-natural woods of this type present today are comprised of abandoned coppice. Rackham (1980) states that coppicing enables more stools of *Corylus* to co-exist with other trees than would normally be possible, and has observed that once coppice has been abandoned, although *Corylus* stools may remain strong for many years, they seem eventually to lose their vigour.

When present in the shrub layer of an undisturbed forest, the major factor affecting its flowering is light intensity. *Corylus* is not very tolerant of shade and flowers poorly if at all in these conditions (Rackham, 1980). Even under a relatively open canopy (about 58% crown coverage, in parts of the Draved forest, Denmark), Andersen (1970) noted that the flowering intensity is low. In these conditions Andersen concluded that the level of pollen productivity of *Corylus* was similar to that of *Fagus*.

The dispersal of *Corylus* pollen produced in these conditions is poor (see Fig A.1). The pollen is mainly released into the trunk space, where the average air speed is low. Therefore the majority of the pollen will be deposited relatively close to the parent plant. Little pollen will penetrate through the tree canopy, due to lack of air turbulance that could move the pollen out of the trunk space and by filtration of the pollen by the canopy cover. The degree of filtration will be relatively low, however, as *Corylus* flowers early, before most canopy trees are in leaf, which lessens greatly the surface area available to intercept the pollen. The pollen grains that do escape may be carried long distances by the higher air speeds above the canopy.

b. *Corylus* as part of the canopy.

When *Corylus* is growing away from shaded conditions it is able to flower more readily and therefore pollen production is higher (Jonasen, 1950; Rackham, 1980). *Corylus*, although now mainly associated with coppicing,

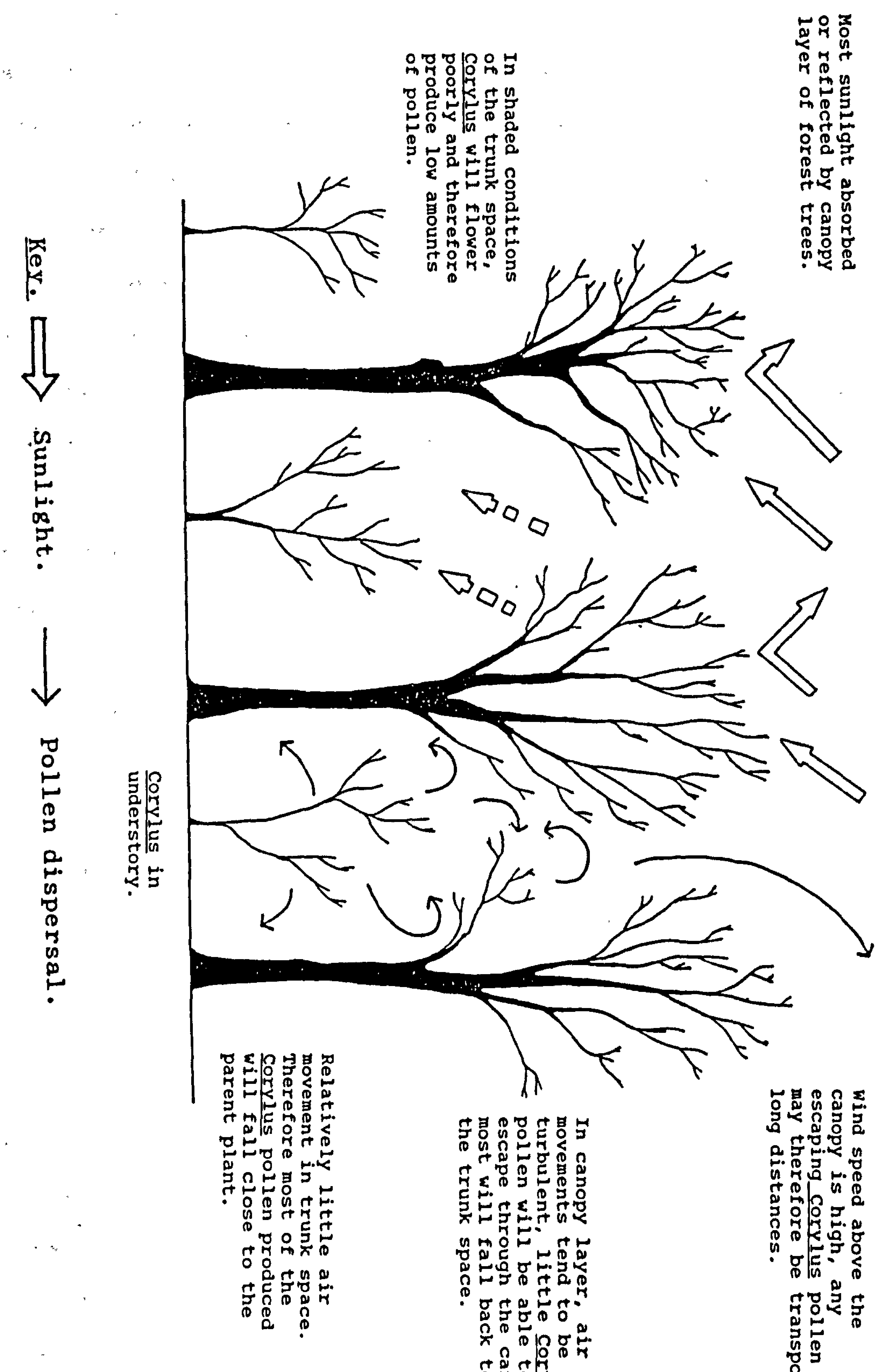


Fig. A1 - Model of the production and dispersal of Corylus pollen when the species is present in the shrub layer of a closed woodland.

is able to grow to the size of a small tree. Today canopy hazels are rare but such communities are still found in oceanic sites such as South-West Ireland and the Isle of Skye. Pollen evidence would suggest that such communites have been more frequent in the past, particularly in the early Holocene. The fact the *Corylus* pollen is abundant in prehistoric deposits, in some areas from Godwin's zone IV onward (Godwin, 1975), suggests that the tree is not always shaded in disturbed habitats and is therefore able to flower and produce pollen readily. It might well have been one of the commonest trees in the past, forming areas of relatively pure *Corylus* woodland (Rackham, 1980). Godwin (1975) noted that pollen production by *Corylus* growing marginally to woods or in clearings could also have been an important contributor to these totals. Pollen dispersal will also be better in these conditions as, although much of the pollen will still enter the trunk space and fall close to the parent plant, some pollen will more readily enter the airstream above the canopy.

2. *Corylus* as coppiced underwood.

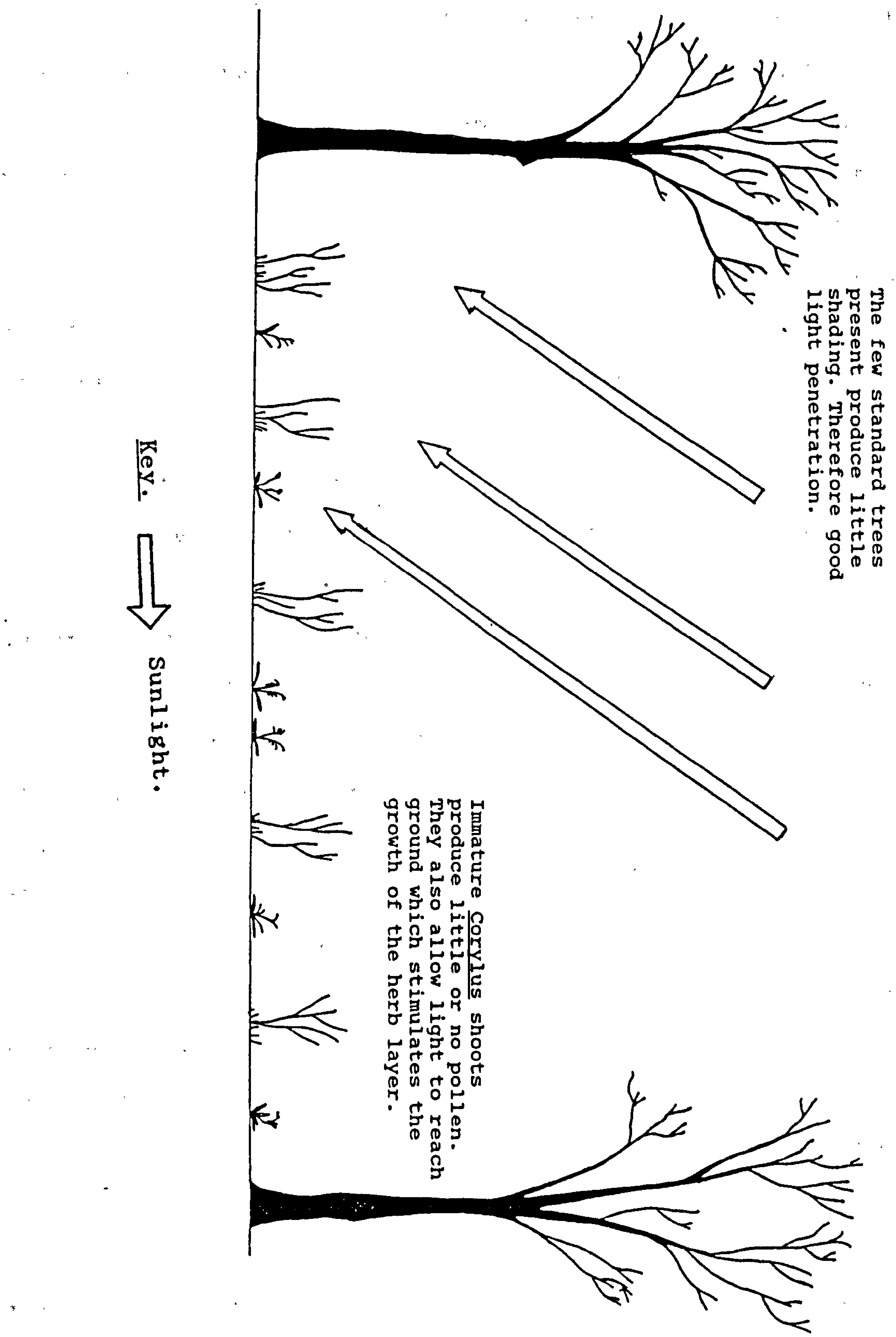
Historical evidence, such as the coppiced hazel poles that make up the Somerset Levels trackways, points to the fact that *Corylus* has been used as underwood from as early as the Neolithic (Clapham and Godwin, 1948). More recently it has been regarded as the most common underwood used in the traditional coppice-with-standards management of woodland. Although other species such as

Quercus spp., *Acer campestre* and *Fraxinus excelsior*, can be coppiced successfully, Rackham (1980) has suggested that *Corylus* is better adapted to coppicing, as it readily forms underground stools and is able to flower and fruit within a shorter coppice cycle than other trees. Just five years may be sufficent time for this to happen. It is of note that the average length of coppice cycles varied historically from 6 years in the thirteenth century to around 15 years in the nineteenth (Rackham,1980). The role of the standard trees, most commonly *Quercus*, in the system is also important. Although there are records of laws being passed setting a minimum number of standard trees to be grown in an area, it must have been important to keep areas of *Corylus* coppice free from shade, because if shaded by taller neighbours, not only flowering but growth rate is much reduced and the stools may eventually die. This would seem to be largely due to the fact that shaded *Corylus* is particularly sensitive to the honey-fungus (*Armillaria mellea*).

The flowering and pollen production of *Corylus* in a coppice cycle can be divided into two stages:

1. Early stages of the coppice cycle, 0-5 years.

In this initial stage after an area of coppice has been cut, the young, immature, shoots of hazel will produce few if any flowers. Therefore, pollen production is low (see Fig A.2a). The other main feature of this period is that the intensity of light reaching the



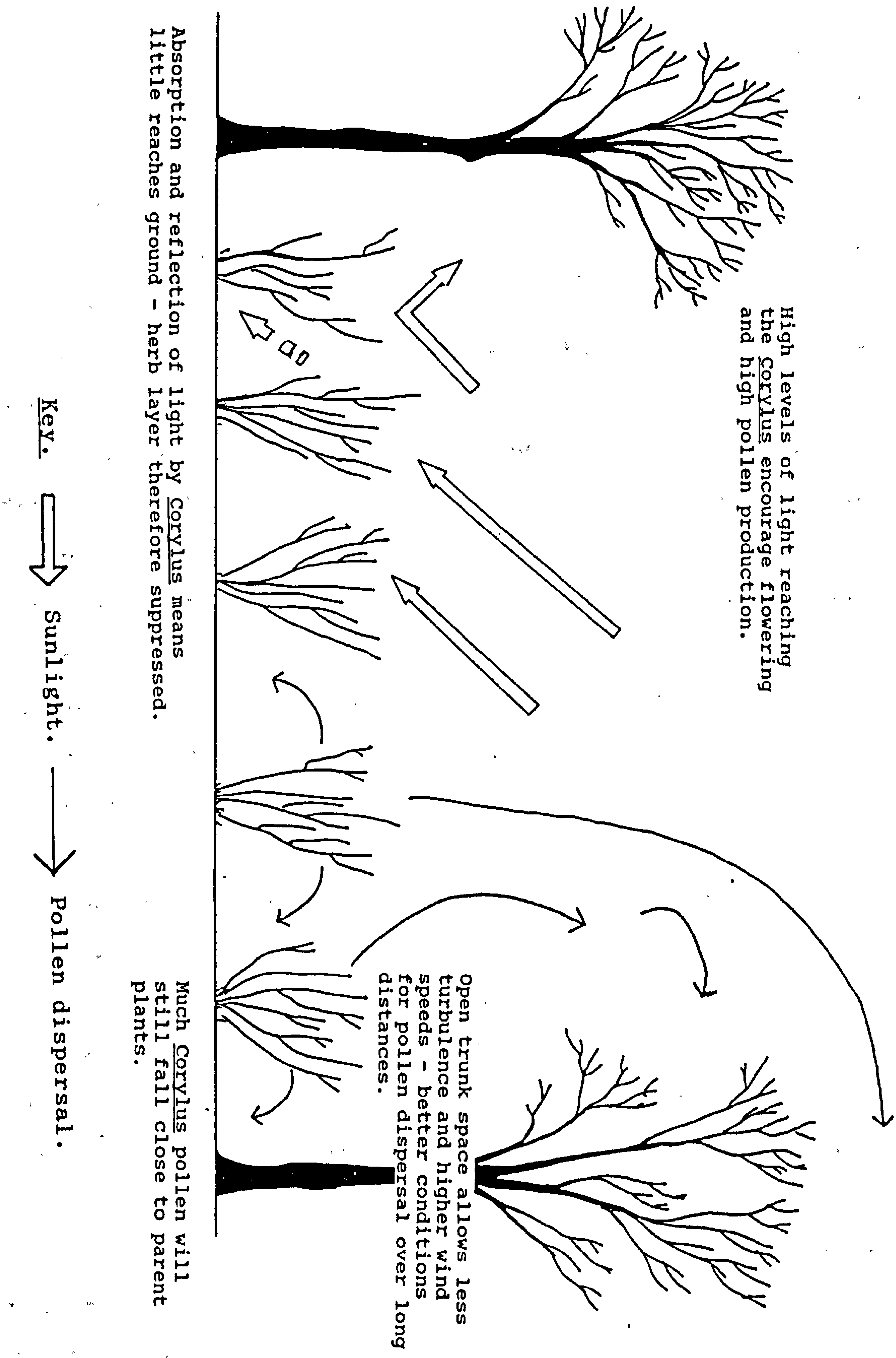
<u>Fig. A2a - Model of production and dispersal of Corylus pollen in coppice wodland: a. the early stages of the coppice cycle.</u>

woodland floor is high and this stimulates the growth of a rich herb layer. It can be seen, therefore, that the pollen output from this system will be low. *Corylus* will produce little pollen and although the ground layer herbs are able to flower, many of the species associated with this stage in the coppice cycle, *Primula vulgaris*, *Ajuga reptans* and *Hyacinthoides non-scripta* for example, are entomophilous and will be poorly represented.

2. Later stages of the coppice cycle, 5 years - harvest.

In the later stages of the coppice cycle the more mature hazel shoots are now able to flower under the open canopy. Therefore pollen production by *Corylus* in these conditions will be high. Dispersal will also be good (see Fig. A.2b). With a very much more open trunk space above the coppice, air speeds will be higher, and there will be a greater chance of *Corylus* pollen being carried above the height of the standard tree canopy where the average air speed will be higher still. The denser cover of *Corylus* has the effect of depressing the amount of light now reaching ground level, inhibiting the herbaceous ground flora.

A major complicating factor, however, is the systematic way the coppice was managed in the past. Peterken (1981) gives the theoretical basic management plan for a forest. If the underwood was cut on a 'y' year rotation then every year one 'y'th of the forest underwood was cut. So that after the harvest the area contained underwood of all ages from freshly cut to (y-1)



<u>Fig. A2b - Model of production and dispersal of Corylus pollen in coppice wodland: b. the later stages of the coppice cycle.</u>

years. Therefore any area of coppice will be made up of a mosaic of patches, each containing *Corylus* shoots of different ages and maturity, with differing levels of pollen production. Although the system was designed to produce a steady supply of timber (and as a consequence, theoretically, a steady output of pollen) each year, such a steady state would be difficult to achieve due to factors such as mismanagement and changes in demand for amounts and size of underwood.

The best evidence of coppicing in pollen diagrams from stratified deposits would appear to be from an increase in the amounts of *Corylus* pollen possibly together with a decrease in the amounts of arboreal pollen. To be able to detect the different stages in a coppice cycle is largely dependent on the size of the pollen catchment feeding the site. If the catchment area is very localised it may be possible to detect the cutting of nearby underwood and possibly even the subsequent increase in the herb layer. If a large catchment area is operating, the theoretical steady state of the traditional management plan would imply a consistent pollen rain from the area, so little if any cyclical changes will be seen. Changes in the management pattern or cases of mismanagement may be visible however.

Obviously the presence of high numbers of *Corylus* pollen accompanied by low arboreal values will not always be indicative of coppice. Spectra, such as this, may be obtained from situations where *Corylus* is forming part of the canopy layer. However, it of note that it has been suggested that, even in the Boreal period, such a vegetation type may have be influenced by anthropogenic factors. Rawitscher (1945) and Smith (1970) both speculated that as *Corylus* is resistant to fire, it would be favoured if fire was used as a management tool by Mesolithic man.

REFERENCES

Aaby, B. (1983) Foret development, soil genesis and human activity illustrated by pollen and hypha analysis of two neighbouring podzols in Draved Forest, Denmark. *Danm Geol Unders.* II, 114, 1-114.

Andersen, S.Th. (1970) The relative pollen productivity and pollen representation of North European trees, and correction factors for tree pollen. Spectra. *Danm Geol Unders.* II, 96, 1-99.

Bates, C.D., Coxon, P. and Gibbard, P.L. (1978) A new method for the preparation of clay-rich sediment samples for palynological investigation. *New Phytol.*, 81, 459-463.

Baker, C.A., Moxey, P.A. and Oxford, P.M. (1978) Woodland continuity and change in Epping Forest. *Fld.Stud.*, 4, 645-669.

Behre, K.-E. (1981) The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores*, 23, 225-245.

Berglund, B.E. (1979) Definition of investigation areas. in *Palaeohydrological changes in the temperate zone in the last 15,000 years. Project guide, vol.1. General Project Description.* (ed. Berglund, B.E.). International

Geological Correlation Programme, Project 158.

Birks, H.J.B. (1970) Inwashed pollen spectra at Loch Fada, Isle of Skye. *New Phytol.*, 69, 807-820.

Birks, H.J.B. (1979) Numerical methods for the zonation and correlation of biostratigraphical data. in *Palaeohydrological changes in the temperate zone in the last 15,000 years. Project guide, vol. 1. General Project Description.* (ed. Berglund, B.E.). International Geological Correlation Programme, Project 158.

Birks, H.J.B and Gordon A.D. (1985) *Numerical Methods in Quaternary Pollen Analysis.* Academic Press, London.

Bonny, A.P. (1976) Recruitment of pollen to the seston and sediment of some Lake District lakes. *J.Ecol*, 64, 859-887.

Bonny, A.P. (1978) The effect of pollen recruitment processes on pollen distribution over the sediment surface of a small lake in Cumbria. *J.Ecol*, 66, 385-416.

Bonny, A.P. (1980) Seasonal and annual variation over five years in contemporary airborne pollen trapped at a Cumbrian lake. *J.Ecol*, 68, 421-441.

Bradshaw, R.W.H. (1981) Modern pollen-representation factors for woods in South-East Engalnd. *J.Ecol*, 69, 45-70.

Burrin, P.J. and Scaife, R.G. (1984) Aspects of Holocene Valley Sedimentation and floodplain development in Southern England, *Proc. Geol. Ass.*, 95(1), 81-96.

Clapham, A.R. and Godwin H. (1948) Studies of the post-glacial history of British vegetation. VIII. Swamping surfaces in peats of the Somerset levels. IX. Prehistoric trackways in the Somerset levels. *Phil.Trans.*, 233; 275.

Cushing, E.J. (1967) Evidence for differential pollen preservation in Late Quaternary sediments in Minnesota. *Rev. Palaeobotan. Palynol.*, 4, 87-101.

Davis, M.B. (1968) Pollen grains in lake sediments: redoposition caused by seasonal water circulation. *Science*, 162, 796-799.

Dimbleby, G.W. (1962) The development of British heathlands and their soils. *Oxford Forest Memoirs*, 23.

Dimbleby, G.W. (1975) Pollen analysis, in Drewett P.L. 'The excavation of a turf barrow at Minstead, West Sussex, 1973', *Sussex Archaeol Collect*. 113, 61-62, 65.

Dimbleby, G.W. (1985) *The Palynoloy of Archaeological Sites*. Academic Press. London.

Drewett, P.L. (1976) The excavation of four round barrows of the Second Millennium BC at West Heath, Harting, 1973-1975. *Sussex Archaeol Collect.* 123, 35-60.

Drewett, P.L. (1985) Excavations of barrows V-IX at West Heath, Harting, 1980. *Sussex Archaeol Collect.*, 123, 35-60.

Evans, A.T. and Moore, P.D. (1985) Surface pollen studies of Calluna vulgaris (L.) Hull and their relevance to the interpretation of bog and moorland pollen diagrams. *Circaea*, 3, 173-178.

Faegri, K. and Iversen, J. (1974) *Textbook of Pollen Analysis*. 3rd Edition by Faegri K., Blackwell, Oxford.

Gallois, G.W. (1965) *The Wealden District*. H.M.S.O. London.

Gauch, H.G.; Wittaker, R.H. and Wentworth, T.P. (1977) A comparative study of reciprocal averaging and other ordination techniques. *J. Ecol.*, 65, 157-174.

Girling, M. and Greig, J.(1977) Palaeoecological investigations of a site at Hampstead Heath, London. *Nature*, 268, 45-47.

Godwin, H. (1975) *The history of the British flora*. 2nd

Ed. University Press. Cambridge.

Harkness, D.D.; Harrison, A.F. and Bacon, P.J. (1988) The temporal distribution of 'bomb' ^{14}C in a forest soil. *Radiocarbon*, 28, 328-337.

Havinga, A.J. (1964) Investigation into the differential corrosion susceptibility of pollen and spores. *Pollen and Spore*, 6, 621-35.

Hill C.R. (1974) Correspondence analysis: a neglected multivariate method. *Appl. Statist.*, 23, 340-354.

Hill M.O. (1979)DECORANA - A FORTRAN program for detrended correspondence analysis and reciprocal averaging. Cornell Univ.

Hill, S.A. (1981) Deteriorated pollen grains and the interpretation of Quaternary pollen diagrams. *Rev. Palaeobotan. Palynol.*, 32, 193-206.

Holmes, G.D. (1975) History of forestry and forest management. *Phil. Trans. Roy. Soc. Lond.* B271, 69-80.

Hyde, H.A. (1952) Studies in atmospheric pollen. A six-year census of pollens caught at Cardiff 1943-8. *New Phytol.*, 51, 281-90.

Jacobson, G.L. and Bradshaw, R.H.W. (1981) The selection of sites for paleovegetational studies. *Quat. Res.*, 16, 80-96.

Janssen, C.R. (1966) Recent pollen spectra from the deciduous and coniferous forests of North-Eastern Minnesota: a study in pollen dispersal. *Ecology*, 47, 804-825.

Janssen, C.R. (1973) Local and regional pollen deposition. in *Quaternary Plant Ecology* (ed H.J.B. Birks and R.G. West) pp31-42. Blackwell Scientific Publications, Oxford.

Jonassen, K. (1950) Recent pollen sedimentation and Jutland heath diagrams. *Dansk Bot. Arkiv.*, 13, 7, 1-168.

Jones, E.W. (1961), British Forestry in 1790-1813. *Quart. J. For.* 55, 36-40 and 131-138.

Jowsey, P.C. (1966) An improved peat sampler. *New Phytol.*, 65, 245-248.

Keating, T.H. (1983) Development of pollen assemblage zones in soil profiles in south-eastern England. *Boreas*, 12, 1-12.

Keef, P.A.M.; Wymer, J.J. and Dimbleby, G.W. (1965) A Mesolithic site on Iping Common, Sussex, England, *Proc. Prehist. Soc*, 31, 85-92.

Lowe, J.J. (1982) Three Flandrian pollen profiles from the Teith Valley, Perthshire, Scotland. II Analysis of deteriorated pollen. *New Phytol.*, 90, 371-385.

Moore, P.D. (1980) The reconstruction of the late glacial environment: some problems associated with the interpretation of pollen data. in *Studies in the Late Glacial of North West Europe* (ed Lowe, J.J., Gray, J.M. and Robinson, J.E.) pp151-155,

Moore, P.D. (1985) Forests, man and water. *Int. J. Environ. Studies*, 25, 159-166.

Moore, P.D., Evans, A.T. and Chater, M. (1986) Palynological and stratigraphic evidence for hydrological changes in mires associated with human activity. in *Anthropogenic Indicators in Pollen Diagrams* (ed K.Behre) pp209-220, A.A.Balkema, Boston.

Moore, P.D. and Webb, J.A. (1978) *An illustrated guide to pollen analysis.* Unibooks. London.

Moore, P.D. and Willmot, A. (1976) Prehistoric forest clearance and the development of peatlands in the Uplands and Lowlands of Britain. *V Int Peat Congress, Poznan, Poland 1976.* 1-15.

Moseley, S.P. (1987) *The vegetational history of the*

Lower Greensand ridge of the North Weald. Unpublished PhD Thesis, King's College, University of London.

Moseley, S.P. and Moore, P.D. (1988) The development of forest in south-east England in the last two centuries: evidence from pollen analysis. in *Human influence on forest ecosystems development in Europe* (ed. Salbitano, F.) ESF FERN_CNR, Pitagora Editrice, Bologna.

Nortcliff, S. (1978) Soils of the Rogate Area. *Rogate Papers*, 2, King's College London.

Peck, R.M. (1973) Pollen budget studies in a small Yorkshire catchment. in *Quaternary Plant Ecology* (ed H.J.B. Birks and R.G. West) pp43-60. Blackwell Scientific Publications, Oxford.

Pennington, W. (1979) The origin of pollen in lake sediments: an enclosed lake compared with one receiving inflow streams. *New Phytol.*, 83, 189-213.

Peterken, G. (1981) *Woodland conservation and management.* Chapman and Hall, London.

Pott, R. (1989) The effects of wood pasture on vegetation. *Plants Today*, 2, 170-175.

Rackham, O. (1980) *Ancient Woodland.* Arnold. London.

Rackham, O. (1986) *The History Of The Countryside*. Dent. London.

Ratcliff, D.A. (1977) Woodlands. in *Nature Conservation Review*, Vol II, p 45-50, H.M.S.O. London.

Rawitscher, F. (1945) The hazel period in the post-glacial development of forests. *Nature*, 156, 302-3.

Ritchie, J.C. and Lichti-Federovich, S. (1967) Pollen dispersal phenomena in artic-subartic Canada. *Rev. Palaeobotan. Palynol*. 3, 255-66.

Scaife, R.G. (1983) *Palynological analyses of West Heath barrows, V, VII and IX, Sussex*. AML Report No. 4002.

Scaife, R.G. (1987) A review of later Quaternary plant microfossil and macrofossil research in Southern England; with special reference to environmental archaeological evidence. in *Environmental Archaeology: a Regional Review Vol. II* (ed. Keeley H.C.) H.B.M.C Occasional Paper No. 1.

Scaife, R.G. and Macphail R.I. (1983) The post-Devensian development of heathland soils and vegetation. in *Soils of the heathlands and chalklands*. (ed. Burnham P.), South East Soils Discussion Group (SEESOIL), 1, 70-99

Smith, A.G. (1970) The influence of Mesolithic and Neolithic man on British vegetation: a discussion. in

Studies in the Vegetational History of the British Isles. (ed. Walker, D. and West, R.G.) pp.81-96., Cambridge University Press. London.

Smyth, C.T. (1988) A palaeaoenvironmental investigation of Flandrian valley deposits from the Combe Haven Valley, East Sussex.

Straker, E. (1931) *Wealden Iron.* Bell, London.

Tansley, A.G. (1939) *The British Isles and their Vegetation.* Cambridge University Press, London.

Tauber, H. (1965) Differential pollen dispersal and the interpretation of pollen diagrams. *Damn Geol Unders,* IIR, 89, 1-69.

Thorley, A. (9171) Vegetational history of the Vale of Brooks. *Inst. Br. Geog Conf.,* Part 5, 57-50

Thorley, A. (1981) Pollen analytical evidence relating to the vegetation history of the chalk. *J. Biogeog.,* 8, 93-106.

Tinsley, H.M. and Smith, R.T. (1974) Surface pollen studies across a woodland/heath transition and their application in the interpretation of pollen diagrams. *New Phytol.,* 73, 547-565.

Tolonen, K. and Tolonen, M. (1988) Synchronous pollen changes and traditional land use is south Finland, studied from three adacent sites: A lake, a bog and a forest soil. in *Lake, mire and river environments during the last 15000 years.* (ed Lang, G. and Schluchter, C.), A.A. Balkema, Rotterdam.

Turner, J. (1962) The Tilia decline: an anthropogenic interpretation. *New Phytol.*, 61, 328-341.

Vuorela, I. (1973) Relative pollen rain around cultivated fields. *Acta. Bot. Fennica*, 102, 1-27.

Wareing, P.F. (1959) Problems of juvenility and flowering in trees. *J. Linn. Soc. Lond.*, 56, 282-289.

Wooldridge, S.W. and Goldring, F. (1953) *The Weald.* New Naturalist Series, London.

Yates, E.M. (1972) *A history of the landscapes of the parishes of South Harting and Rogate.* Phillimore & Co. Ltd., Chichester.

Yates, E.M. (1988) The vegetation of Ebenoe Common, Sussex: an historical and botanical survey. In Press.